PRODUCT ENGINEERING

MARCH, 1943

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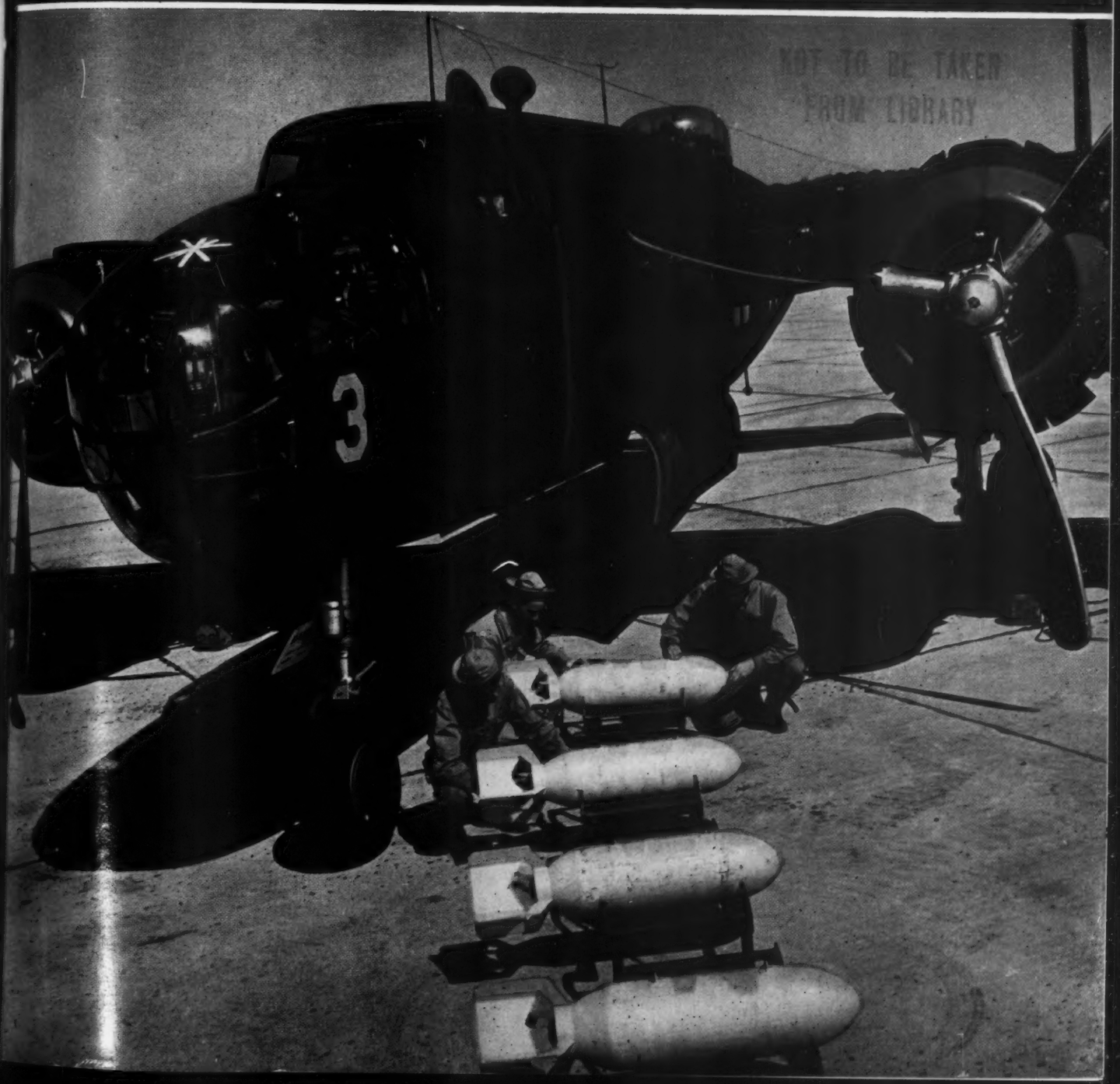

How INCO Technical Service helps you conserve critical materials

No matter whether newspaper headlines feature priorities, "PRP", or the Controlled Materials Plan, the need for conservation never lessens. The war must be fought and won. That means critical materials by the carload.

Perhaps you know that every pound of alloy must give maximum service if our far-flung fighting forces are to be supplied and maintained. Nickel, particularly, is needed to give wartime steels greater strength, toughness and resistance to impact.

INCO's technical staff is organized to serve users of metals and alloys—to help manufacturers find and adapt alternative materials without sacrificing desirable and essential characteristics in the finished product.

So if you have a problem involving the use of alloys—Nickel or otherwise—please write or wire for data or counsel from our technical staff.

NICKEL

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK, N. Y.

PRODUCT ENGINEERING

VOLUME XIV MARCH, 1943 NUMBER 3

IN THIS ISSUE

Visualizing in Three Dimensions

Efforts to keep tooling costs within certain limits led Fleetwings, Inc., to try to find a simple, quick and inexpensive way to give the tool department an idea of what had to be built so that estimates of costs and dies necessary could be made prior to release of complete airplane drawings. Graphic illustrations, or visuals, were the result. Now practically every department in the company uses them.

Visuals are not meant to take the place of engineering drawings. Rather, they supplement them by giving a clear, quick picture of an assembly described in detail drawings. The uses which Fleetwings has found for visuals, and how they were developed, is described in the article beginning on page 131.

Fatigue Stress Concentration Factors

More on stress concentration factors in this issue takes into account the effect of fatigue. Several additional cases are considered with particular emphasis upon their practical use in design. As in last month's article, the author, George H. Neugebauer, Department of Machine Design, Cooper Union, has examined and evaluated the results of numerous investigators with respect to dependability in application to design of structural members. His article is on pages 168 to 172.

Plastics for Electrical Applications

A wide variety of plastics are available for use where electrical insulation is required. Which particular one to use will depend largely on the temperature and humidity conditions that the part will encounter in service and the dielectric strength that will be required. On page 165 begins the article "An Aid to Selecting Plastics

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for Electrical Applications," wherein we have tabulated the electrical properties of the various types of plastics and analyzed the kinds of service for which each is suitable.

Tube Spinning Methods Announced

A new process by which tube ends can be formed to almost any desired shape with or without being closed, is offering new simplification in design, elimination of production processes and saving of time. Walter P. Hill, inventor of the process, was one of 10 men given awards by President Roosevelt in recognition of noteworthy contributions to the war effort. His contribution was this process applied to the manufacture of primer tubes used in the firing mechanism of large shells. Several typical redesigned parts are suggested by the article on page 153.

Commercial Tolerances for Springs

Spring manufacturers are having difficulties because of the tendency of individual manufacturers to vary from commercial tolerances previously agreed upon and the lack of appreciation on the part of designers of the necessity for larger tolerances than generally used for machined dimensions. Harold Carlson of the Lee Spring Company offers a solution to the problem by presenting easily read tolerances in tabular form. See pages 156 and 157.

Fine Wire Magnet Coils

For coil designers who are continually on the watch for information concerning properties of insulation materials that can be used in the construction of fine wire magnet coils, the article, beginning on page 158, is a "must." In it B. W. Erikson, Industrial Control Engineering Department of the General Electric Company, enumerates the causes of corrosion failures with particular emphasis on the ravaging effects of moisture. Many remedies are described to eliminate this trouble. Some test data are also included.

Plywood Design Kinks

For engineers trained to design structural members and machine parts of various metals and ferrous alloys, the use of plywood seems to have many mysteries. Its extensive application in aircraft at present has stimulated the formulation of certain rules to be followed in joining wood members. The article starting on page 149 shows some of the principal rules which can be applied to any kind of plywood structure where high strength and light weight are to be combined.

Forgings to Castings

When cast iron can be used instead of forged steel in crankshafts 9½ in. in diameter and 10 to 15 feet long, as is done on such shafts for compressors built by Cooper-Bessemer, it is evident that high strength cast iron has arrived. Nearly the whole line of York refrigeration compressors are now being equipped with cast iron shafts. See the article on page 161 which explains how it was done.

Liquid Adhesive Applicators—II

The ten ways of applying viscous liquid adhesives in automatic machines that were illustrated last month were not enough to cover the field, so a similar number of such mechanisms are presented again in this issue. There are, of course, many other mechanisms in use but it is believed that with this group on pages 173 and 175, most of the general classes of applicators have been shown. All will suggest similar designs for other specialized uses.

Arc-Welding Reduces Weight

By telling how Nordberg Manufacturing Company capitalized on the increasing use of arc-welded construction of parts of large diesel engines, Assistant Chief Engineer Robert Cramer, Jr., won a prize in the recent $200,000 Industrial Progress Award program of the James F. Lincoln Arc Welding Foundation. Weight reduction and better appearance are among the advantages. The improvements described in the article on pages 176 to 178 were made without any change in the basic structure of the engine.

Section Properties At All Angles

Formulas for determining moment of inertia, section modulus and radius of gyration for a rectangular section at any angle are given in recognized handbooks. Since these require considerable pencil work and time to figure out, the two nomograms on pages 189 and 190 were constructed to shorten the job considerably. Not even a slide rule is necessary to find the right size and shape of section.

WHAT'S COMING

Highly Stressed Studs

The article on highly stressed studs, scheduled for this number of P.E., got tangled with censorships. We are glad to report that the tangles have been ironed out without detracting from the technical value of the article. It will be published soon.

Shrink Fits

Shrink fits date all the way back to the days when carriage makers of old shrank a steel rim on the wooden wheel. Steel rims shrunk on the driving wheels of locomotives were a natural development. But the high temperatures required limited the application of the process. Now, however, the development of freezing equipment to shrink the male members has opened a vast new field of possibilities for the use of this type of assembly. General opinion is that shrink fitting is primarily for the purpose of obtaining a semi-permanent assembly. However, the process is also used to position sleeves before welding, to assure complete metal-to-metal surface contact, to avoid any possibility of pounding between the two parts and, finally, to prestress the assembled unit to give it greater strength. Tolerances used, stresses developed and other design data will be included in a comprehensive article to be published on this subject.

A New Surface Treatment

Under the tradename of Kolene there has been developed a new surface treatment which according to tests by users produces a highly superior bond between babbitt and cast iron or babbitt and steel without the use of an appreciable amount of tin. The coating made by this process has the further advantage of being highly corrosion resistant. Equipment required, the operation of the process and a complete analysis of the results obtained will be included in an article on this subject.

Textiles—in War as in Peace

World's oldest industry performs modern miracles

WITH ever quickening tempo the friendly hum of the spinning wheel has echoed down the centuries—symbol of a mighty industry.

Its hum is heard today above the din of war.

Capt. Rickenbacker heard it as the lives of his party depended upon a thickness of rubberized fabric.

The hard-pressed soldier on a far-off Pacific isle hears it when he sees fresh supplies and ammunition descending from the sky via friendly parachute.

Adolf Schickelgruber hears it when winter joins forces with the enemies of his ill-clad armies and hastens the day of his defeat.

Yes, man is dependent upon textiles from the cradle to the grave – in peace and in war.

In peace man demands comfort and beauty. In war he must have comfort and protection. The textile industry is coming up to these expectations.

It is developing hundreds of special fabrics for special purposes. It has created clothing for wear, miles high in the stratosphere, and fathoms deep under the sea, clothing to meet the daytime heat of the desert and the bitter cold of its nights, clothing for the tropics and the Arctic, the swamps and mountains –for every climate and every condition.

Modern scientific warfare has forced the development of textiles that were not even thought of a year or two ago: camouflage nets; strong, light, wind-resistant Nylon tentings for the Arctic; heavy Nylon rope for glider towing; parachutes and parachute shrouds; self-sealing gas tanks; panzer hangars; cartridge and powder bag cloths; helmet linings; gas masks; fuses; canvas tops; windshield fabrics and seat upholstery for jeeps, trucks and other motorized equipment; uniforms for all armed services and for nurses, WAACS, WAVES, SPARS and MCWRS. Then there are windbreakers, raincoats, ski-troop uniforms and other items two numerous to mention. The Star Spangled Banner itself is a textile.

The Quartermaster Corps alone has issued specifications for over 300 different fabrics! Add to this the requirements of the Navy, the Air Forces, the various Civilian Defenses, the Red Cross and Lend-Lease and the sum total of textiles required for military and allied uses is approximately 70% of the total produced before the war to meet civilian requirements!

How the textile industry has been able to meet this unprecedented war demand, superimposed upon the industrial and essential civilian needs, is an inspiring story.

First, it stepped up its production to an all-time high. *Textile World's* index of textile-mill activity records three successive records for 1940, 1941 and 1942, the period covering the defense program and the first year of the war. This index for 1942 stood at twice that of an assumed "normal" year. It is noteworthy that this was accomplished mainly with existing equipment.

Second, the textile industry did a job of plant-conversion which was a masterpiece of intra-industry cooperation and idea-sharing.

Third, its technicians developed new and superior fabrics and finishes. Its engineers and production men increased the speed and the efficiency of the entire production machine.

How well all this was done becomes evident when we consider the obstacles to be overcome. Imports of critical fibres have been cut off. There is a shortage of certain chemicals and dyes. There is a high rate of turn-over in manpower and a shortage in experienced labor. It is increasingly difficult to secure machines and repair-parts – just to mention a few of the major problems.

But the textile industry delivered. It has built up an adequate reserve for our rapidly expanding armed services. It is helping to supply the armies of our allies. It is providing for our civilian population . . . all without giving the war leaders a single moment of serious worry.

Major General Edmund B. Gregory, Quartermaster

This is the ninth of a series of editorials appearing monthly in all McGraw-Hill publications, reaching more than one and one-half million readers, and in daily newspapers in New York, Chicago and Washington, D. C. They are dedicated to the purpose of telling the part that each industry is playing in the war effort and of informing the public on the magnificent war-production accomplishments of America's industries.

General of the United States, in special statements prepared for *Textile World*, and in addresses before textile groups, has stated that the cooperation of the textile industry has been outstanding and that the industry has kept ahead of schedule on all the major types of fabrics required.

General Gregory recently pointed out that of the approximately 234,000,000 yards of combed twill produced in this country in 1942, the Army took about 87%, the Navy 10%, leaving 3% for non-military purposes.

Col. Robert T. Stevens, of the Quartermaster Corps, in a recent address, referred to the output of duck. Production of that vital military fabric was twice doubled in six months, between January and July 1942, he said, and an annual capacity of 600,000,000 yards of all types of duck was made available. "The current rate of production of cotton duck is five times normal," said Col. Stevens, "and 38% comes from converted carpet, plush and upholstery mills. Based upon known requirements, production in this field is fully adequate".

"Fully adequate" is high praise when it refers to duck production. At the outbreak of the war it looked as if there was no possible chance of meeting requirements, at least during the first year. Nor would there have been if other types of mills had not shifted to making this fabric, and if experienced duck manufacturers had not gone "all-out" in teaching the newcomers, potential post-war competitors, everything they knew about the manufacture of duck. American industry offers many such examples of unselfish cooperation.

Another outstanding accomplishment, made necessary by the interruption of burlap imports, was the conversion of looms producing peacetime fabrics to the production of bag fabrics. The tremendous demand for sandbags, camouflage cloth, food, agricultural and other bagging, caused a conversion order to be issued for the purpose of raising the annual production rate of osnaburg from 263,500,000 yards to 660,000,000 yards, and bag sheeting from a rate of 488,000,000 yards to 855,000,000 yards. The result of this order, and of the military schedules already in effect, was to put the cotton weaving industry about 88% into war, essential industrial, and essential civilian production.

Plant conversion went on with feverish speed. Carpet looms were swung to blankets and duck; the lace industry turned to mosquito netting and insect netting of which it produced millions of yards. The flat-knitting industry with its tricot machines also is engaged in the manufacture of mosquito netting. The sewing thread industry was converted to the production of combed yarns. What once was the silk industry is now doing a tremendous amount of war work. Those mills which had equipped themselves for throwing Nylon yarns for hosiery are now throwing the Nylon for parachutes. That section of the silk industry that was equipped for weaving rayon fabrics is producing fabrics of high-tenacity rayon for flare chutes, cargo chutes and delivery chutes. Many silk and rayon looms that formerly wove clothing materials are now weaving parachute fabrics.

Today practically all Nylon is used for military purposes and the bulk of high-tenacity rayon goes into military fabrics.

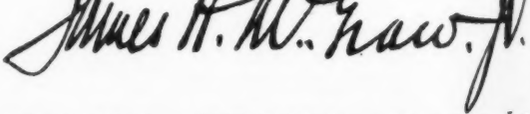
Above and beyond all the new developments is the gigantic job of producing millions of yards of standard fabrics of many colors and weaves. To produce all the uniform fabrics and blankets is in itself quite a job. The woolen and worsted industry has been doing it magnificently. Tent fabrics and summer fabrics produced by the cotton industry are no less a formidable assignment. I could point to myriad other jobs no less impressive.

The production man can indeed take pride in this record and behind the production man, the textile technician has been working tirelessly. Mildewproofing and waterproofing, so vital in a world at war, are in a new stage of effectiveness. A new process for waterproofing fabrics employs vinyl acetal plastic in place of precious rubber. Textiles that glow in the dark have been perfected for black-outs and other applications. American genius is solving problems many of which seemed insurmountable. Silk, for example, was something the Japanese thought we could never duplicate. A new synthetic textile filament that weighs but one eighth of the finest silk filament threatens to put the Japanese silkworm out of business after the war so far as we are concerned. The post-war possibilities of this development challenge the imagination.

Nor has the primary textile industry been alone in its contribution to the war. The textile machinery industry has been converted almost entirely to war work, save for a few facilities required to relieve extreme bottlenecks and supply essential maintenance and repair-parts.

Similarly, some textile mills, particularly hosiery mills hard hit by the silk and Nylon cut-off, are utilizing their space and skilled staffs to produce parts for war equipment.

The immediate significance of all this is its importance in the winning of the war. There is, however, a post-war implication which is important to the future of America. A mass production textile industry will serve civilians after the war more effectively than ever before, and will put new standards within the reach of millions. A long step has been taken toward that completely synthetic textile industry which some observers see in the future. The tempo of such changes has been accelerated tremendously. The oldest industry in the world, now one of America's largest, is showing a youth and vigor that promise much for the future... nationally and internationally.



President, McGraw-Hill Publishing Company, Inc.

PRODUCT ENGINEERING

GEORGE F. NORDENHOLT, *Editor*

Professional Status After the War

WHAT WILL BE THE STATUS of engineering as a profession and what will be its opportunities in the post-war period? These questions have created a great deal of speculation. Possible answers are indicated by the record of engineering in the preparation for and the conduct of the war and the public recognition thereof. A brief review and analysis of this record reveals some fundamental reasons why engineers are inherently fitted for the type of leadership that will be required after the war.

When in 1940 it became obvious that the U.S.A. would soon be forced to fight, the government sorely needed guns, tanks, shells, ships and other fighting equipment. Before manufacturing could be started, designs and working drawings had to be produced. Engineers in industries and universities were assigned to help the Ordnance Department, Signal Corps, Air Forces and other branches of the services to develop new fighting equipment and improve existing models. Manufacturers received from the services layouts and specifications and the engineering departments of industry made the necessary working drawings. At every step in the vast program of converting from peacetime activities to war production, engineers were called up to advise, suggest, make decisions, and bring forth results.

The leading role played by engineers in the war effort has not been confined to the design and manufacture of the material needed. When the job of building a huge fighting force began, the Army turned to engineering students and engineering graduates for their best officer-candidate material. The Army's preference for engineers is not only because this is a war of machinery but also arises from the fact that the mental training given to technical students is peculiarly suited to military needs. Annapolis and West Point graduates are as well grounded in engineering as are the graduates of technical universities. Mathematics, physics and chemistry, the fundamental subjects in every engineering curriculum, are exact sciences. Two plus two always equals four; action and reaction are always equal; energy can neither be created nor destroyed. These and a host of other axioms and their applications are thoroughly drilled into the minds of the students. The recognition of the unyielding inflexible truths of the laws of nature makes realists of the students. Only realists can contend successfully with the many problems involved in this war which is so vastly different from any previous one because of its magnitude, the scientific character of the fighting equipment and the vast distances involved.

Thus it is that the engineering profession is now in the forefront as it never has been before. The public fully recognizes its importance. Engineers have become indispensable not only in the conduct of the war but also in the every day problems of civil government.

Will the engineering profession maintain its outstanding position after this war is over? There are many reasons why it should. Problems of the post-war period will have their roots ever deeper in science and technology. The significance of this in relation to the responsibilities of engineers is obvious. Whether or not the profession will measure up to its post-war opportunities depends entirely on the attitudes and activities of its individual members.

WARTIME DESIGN NEWS

WILSON WINS OUT:

WPB, which essentially is supposed to equip the armed services to fight, has a combat record almost equal to that of the services—and covering about as many fronts.

Trouble is, WPB's fighting hasn't killed any Germans, but has only succeeded in baffling the public at large. Its latest scuffle resulted in a complete victory for Production Boss Charles E. Wilson, when program vice-chairman Ferdinand Eberstadt was ousted by Chairman Donald Nelson in an attempt to end finally the intra-agency warfare. Admittedly, this is a sorry substitute for a second front.

Wilson won out in a comparatively short time and over a formidable opponent, for Eberstadt swept all before him when he transferred to WPB from the Army-Navy Munitions Board.

The fight was brewing late last year when WPB regained the control over production Chairman Donald M. Nelson had assigned to the military almost a year ago. With those powers back in the hands of Wilson, who had been brought to Washington specifically to handle the scheduling job, the old conflict was replaced by a new one, that of which WPB faction was to have control, scheduling or allocation.

Eberstadt came to prominence when the problem was to limit the various programs, both facilities and war output, to the amount of material available. This job Eberstadt did with dispatch, also instituting the Controlled Materials Plan which will see to it that no more priorities checks are written than can be cashed at the materials bank. That much had been done, however, by the Production Requirements Plan. CMP's other facet aims at correction of an evil of nonfeasance which wrecked PRP—the failure to balance production, to assure a motor for every airframe, a track for every tank, reduction gears for every ship—and on time.

CMP, of course, hasn't really been tested yet. It doesn't go into effect formally until July 1, although many companies will govern their material supplies under it during the second quarter, when a test-run will be in progress. But the plan is there, and unless it proves an utter failure, it probably will stay, for materials allocation is not a field which can be governed by a new plan every few days.

With these two needs provided for, Eberstadt's main job is done. True, he must make CMP function effectively and keep tight control over the availability of materials, particularly steel, copper and aluminum, the three controlled materials. But any progress from that point must come from the best possible utilization of the materials which are to be had, and this is a scheduling job rather than an allocations job. The functions are widely at variance, and Wilson's is the job now on the firing line.

The "fight" aspect enters the picture from several angles, the most recent of which is the transfer from Eberstadt's domain to Wilson of the WPB General Industrial Equipment, Shipbuilding, Automotive, Machine Tools, Safety and Technical Equipment, Aluminum and Magnesium and Facilities branches. Loss of these important organizations was regarded as a severe blow to Eberstadt's competitive prestige if not actually to his sphere of influence. They went to Wilson only after considerable soul-searching on the part of Boss Nelson, who regarded the switch as necessary to permit Wilson to do the best possible job, particularly in boosting production of critical components, currently the principal arms bottleneck. Eberstadt's demise leaves Wilson in control of all WPB functions as executive vice-chairman. Originally the row had been settled to leave Wilson in charge of branches dealing with end products and Eberstadt in charge of branches handling materials. The Aluminum and Magnesium Branch, not concerned with an end product, went to Wilson because he is the final aircraft boss, and 80 percent of the nation's aluminum production goes into aircraft. The Facilities Branch went to Wilson inasmuch as any new production facilities would come under its supervision, and Wilson is charged with increasing lagging component production.

The situation was provoked by a Wilson edict that all orders for critical components to be delivered during the first half of 1943 were to be on the books early in February, and those for second-half delivery placed by March 1. Eberstadt protested the move on the basis that it broke up a smoothly-running organization, that it conflicted with certain of his instructions under CMP and that it placed too great a burden on industry.

Another fight angle, which may or may not have had anything to do with the situation in question but which must inevitably underlie all Wilson-Eberstadt differences, is the Army-civilian angle. Wilson is strictly a civilian, formerly president of one of the nation's greatest manufacturers. Eberstadt is a banker who came to WPB from the chairmanship of the Army-Navy Munitions Board. One of the continuing feuds of wartime Washington is that over control of war production. Wilson has been regarded as a champion of civilian control, Eberstadt of control by the services.

POSTWAR DESIGNS NOW?

The National Automobile Dealers Association listened at length recently to a detailed explanation of the Nugent "pay-for-it-now-get-it-later" plan. Then, by formal vote, it announced its opposition to the latest anti-inflation device to come out of Washington.

By this blunt action, the car dealers probably called a halt to an idea which might have had broad repercussions among design engineers, for without their support, the plan, at least as proposed, probably has small chance of adoption.

The Nugent plan, so called because is was advanced officially as a measure to be government-sponsored by Rolf Nugent, a special adviser at the

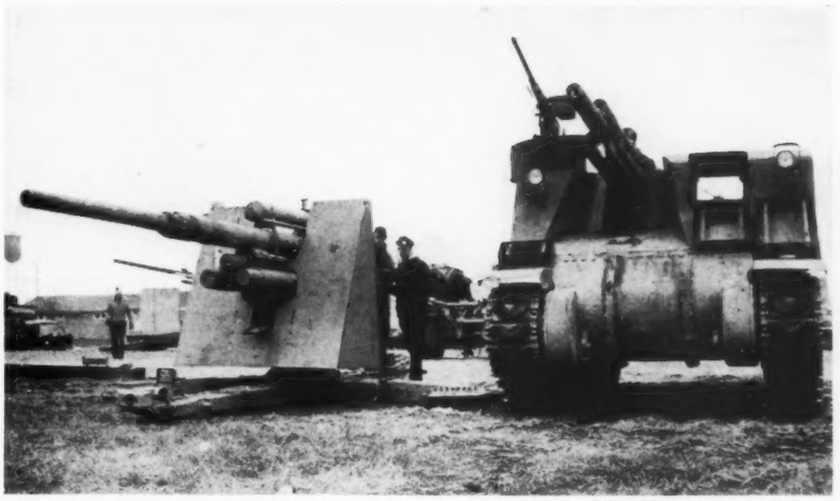
Office of Price Administration, would put the government in the business of selling securities now which would be cashed in after the war for such consumer goods as automobiles, electric ranges, heating systems, pianos, refrigerators and what have you. The securities would appreciate in value from $1 to $1.10 if applied to postwar purchases, or would be redeemable at the regular sale price at any time. They would be issued for specific purchases and would entitled the holder to a priority on the first postwar merchandise. Order among holders would be determined by date of purchase, and there would be no free market for any item covered by the plan until all securities had been exchanged for the item called for. Prices quoted now would be only approximate.

Mechanics of the scheme call for the government to establish a Post-War Delivery Corporation as subsidiary of the Federal Reserve System to supervise the plan. Sales would be made by established dealers. Books would be kept by finance companies. Utilities would collect the payments through their own existant collection facilities. The Treasury would pay modest commissions to each participating agency. The appreciation on each certificate would be split 30-70 between the manufacturer and dealer.

So much for the plan itself, which thus far has stirred up as much distaste as did the Ruml plan for pay-as-you-go income tax collections when it was brought out late last summer. Much of the opposition to the Nugent plan comes from Treasury Secretary Henry Morgenthau, chief opponent of the Ruml plan, incidentally. Thus far, at least, it seems to be based on Morgenthau's principal complaint against the Ruml plan—the fact that some one else thought of it first.

But, as witnessed by the auto dealers' verdict, the plan has stirred up opposition in other than official quarters. Business men question the Nugent plan specifically because they think that, being government-sponsored and operated, it would extend wartime controls into peacetime operations in the form of price stabilization and material allocation. If some such plan or plans were to be established independent of government administration, one of the principal objections to it would be removed. Actually, a plan which is basically similar, but privately operated, is flourishing today in Hartford, Connecticut, where the Hartford Electric Light Company is operating its deferred delivery purchase plan for refrigerators, ranges and hot water heaters. The company sells War Bonds which carry post-war delivery priorities.

All this, of course, is of bread and butter interest to the men who will have to design the products which are to be exchanged for whatever deferred delivery certificates which may be sold. If the early post-war days of the last war are any criterion, the United States citizen, when this hard war is over, will be longing for an



Official Photograph U. S. Army

Here are the arch enemies of the North African desert, the German 88-mm. antiaircraft-anti-tank gun, left, and the U. S. M-7 mobile howitzer, (PRODUCT ENGINEERING, Jan., page 31), nicknamed "The Priest" by the British who used it first to dislodge Rommel at El Alamein, then to chase him across the continent. Poor features of the German gun include a three-piece barrel, of a type made in U. S. in 1910–1912; light metal shield, vulnerable to 50-cal. machine gun fire; traverse limited by length of various control cables. Also, the gun can be turned in a complete circle only twice, then must "unwind." The picture was taken during comparative tests at Aberdeen Proving Ground, Maryland, which showed the comparable U.S. gun, a 90-mm. weapon, superior in range, rapidity of fire, striking power and maneuverability. Our gun has a single tube barrel, which the Germans cannot use, and it has no limitations on turning.

Official Photograph U. S. Army

German "Volkswagen," right, is superior to the U. S. "jeep" only in the impressiveness of its name, according to results of tests made at the Aberdeen Proving Ground, Maryland. The "Volkswagen," or people's car, makes 30 m.p.h., the jeep 50 m.p.h. It has a two-wheel drive, the jeep two or four-wheel drive. In rough country, the "Volkswagen" isn't as good.

early return to "normalcy." If he has laid by sizeable chunks of war income for post war aids to better living, particularly automobiles, "normalcy" will include speedy redemption of the deferred delivery certificates. And if the promised merchandise is to be at all readily available, it will have to be designed, approved and ready to go soon after the war ends. This will present no great problem in the matter of coffee percolators, but will be something else again in the automotive field.

Some may argue that designs for post war consumer goods are completed now, lying in manufacturers vaults awaiting only the reconversion to peacetime operating conditions. Indeed, some manufacturers have been advertising as much for months.

There is some reason to believe, however, that designs completed too far ahead of the delivery date will be at a competitive disadvantage with products engineered on the basis of later information and techniques. A designer, for instance, who a year ago closed the forms on a commodity containing any great amount of plastics could find his product out of date today, so great has been the development of plastics in the last year. Sometime, of course, designs of postwar products will have to be completed, regardless of what lies in the future. But it will take some cagey guessing as to how much longer the war will last, how quickly reconversion can be effected and in what direction public taste will venture before any specifications for a postwar product can safely be completed and put away to await peacetime use.

One interesting angle to the whole idea is that of manpower—designer manpower. The Presidential directive under which Labor Czar Paul McNutt operates specifically provides that no employer may retain the services of a man who is more valuable elsewhere. Suppose a company feels that it can spare from its war work the services of one or two design engineers to do the spadework in revamping its peacetime line. Suppose another company, for any of a dozen reasons, needs a designer or two—for war work. Under the terms of the manpower directive, the answer is obvious. Incidentally, thus far there is no legal provision binding an employer who loses a man under such circumstances to re-employ him after the war.

At this writing, prospects of the Nugent plan becoming an established policy do not look good. The idea, however, has sufficient attraction to spring up locally as it has done in Hartford. No less a personage than shipbuilder Henry Kaiser has espoused the principle enthusiastically.

CM PROGRESS:

Ferdinand Eberstadt's Controlled Materials Plan marched along smoothly on schedule and, somewhat simplified, met its most important deadline thus far Feb. 1 when WPB's Requirements divided 17,000,000 tons of steel, 600,000 tons of copper and 600,000,000 pounds of aluminum among 14 claimant agencies.

Biggest noticeable change in the plan was in the number of shares. Starting with seven, CMP doubled its claimant agencies in three months to include the WPB Facilities Bureau, National Housing Administration, Petroleum Administrator for War, Office of Food Administrator, Office of Defense Transportation, Office of Rubber Director and Office of Power Director.

As might be expected from the foregoing list, the "must programs," rubber, high-octane gas and escort vessels, got fullest consideration, while less essential programs were cut to the bone. As it was, carbon steel requests exceeded supply by 17 percent, alloy steel was 15 percent high, copper 16 percent oversubscribed and aluminum 14 percent high. Allocations were made for the second quarter of 1943 rather than monthly.

DIE-CASTING ADOPTED:

WPB has instituted a system for certification of die-casters assigned to produce high quality zinc and aluminum castings for ammunition components. The plan will be operated by the Conservation and Substitution Branch of the Conservation Division. Any die-casting company may request certification of the Conservation Division. The plan will require rigid inspection of castings to insure perfect components. Spectrographic and X-ray inspections will be made of the zinc castings. Aluminum castings will be tested by means of the X-ray process.

MATERIALS:

Tungsten contact points have been released from allocation control under an order allocating tungsten rod, whence points are made.

Plastics molding machinery is under allocation control. No such machinery may be delivered or accepted except on specific authorization of WPB, nor may it be manufactured or assembled except to fill specifically-approved orders.

Tin consumption allowed by WPB for 1943 has been chopped 12,000 to 15,000 tons, leaving this year's supply at half that of 1941. Principal savings are to come from a 10 percent reduction in the amount of tin allowable in solder.

Lead supply this year will be somewhat below that available in 1942, but it will cover presently-known requirements and leave a margin for stockpiling. Less essential uses may suffer if much more substitution of lead for more critical metals is engaged in.

Alloy steel may no longer be used in angledozers, bulldozers or repair parts for either.

Valves such as gate, globe, angle, cross and check types take a 50 percent slash in allowable types in Order L-252. Cross valves are completely eliminated, as well as brass or iron check valves.

Allowable sizes and types of portable jaw crushers and roll crushers have been slashed drastically under Order L-217, Schedule II.

TRENDS:

Manpower control is tightening all along the line. Labor Boss McNutt has ordered establishment of hiring controls in all labor shortage areas and warned that similar controls would be instituted in less critical areas if the regional manpower committee feels they are required. . . . Concrete evidence of the swing away from facilities construction to intensified production is the announcement that projects to cost $1,271,389,309 were cancelled between the end of October and the beginning of February. . . . An example of the distortion possible in wartime Washington is found in reaction to Civilian Supply Chief Joseph L. Weiner's report that, if need be, U. S. civilians could get along with 23 percent less in goods and services than they're slated to get in 1943. In setting the "bedrock" figure at $56,000,000,000 a year, Weiner mentioned that the necessary liquor consumption could be reduced 99 percent, bringing screams from wet Congressmen that "backdoor Prohibition" was in the wind. Weiner doesn't expect 1943 consumption to reach bedrock although it is near it in metals and rubber and may reach bottom in several other fields by the end of this year. Bedrock, he said, is 32 percent below 1941 consumption totals. . . . Public transit, swamped by the ban on pleasure driving, will be given high priority on critical materials for construction and maintenance.

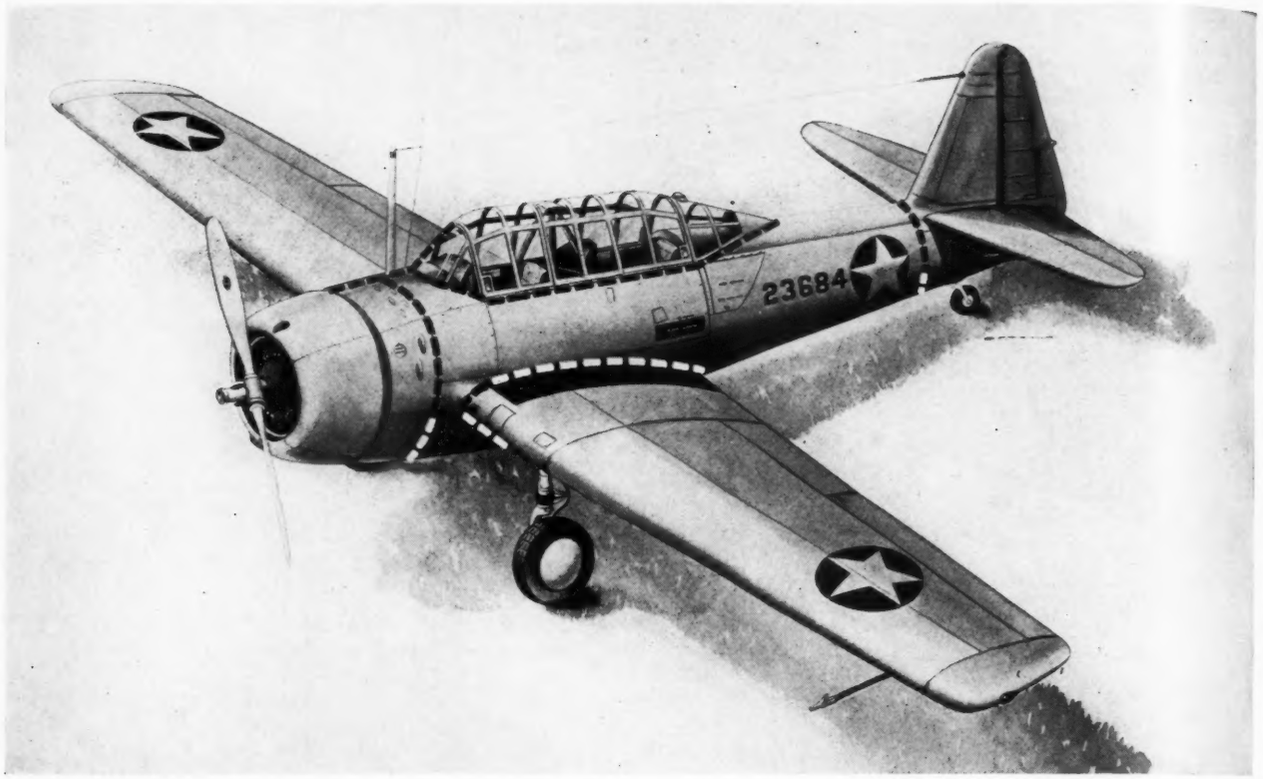
Visualizing in Three Dimensions

Graphic illustration is the newest tool for engineers to use in putting ideas and explanations on paper. In a sense, visuals, as graphic illustrations are called, are perspective drawings with the accuracy and completeness of the best engineering drawings. The experience of Fleetwings, Inc. is that good commercial artists make better graphic illustrators than do draftsmen. The effectiveness of visuals depends on how carefully they are made and how widely they are used. Visuals catch "bugs" before production is started.

HOW to put the engineer's ideas on paper so that they can be understood by anybody has long been a problem for both designers and draftsmen. This problem arises not so much because management and administration executives sometimes are not able to visualize from blueprints easily and quickly exactly what is intended but because frequently the foremen in the shop are not experts in reading orthographic projections, a fact which has been greatly emphasized by present conditions. If, by any chance, the drawing is the kind that would present a clear picture to non-technically trained people, it is not suitable for the engineers and production men.

The aircraft industry began to furnish the answer to this problem when Douglas Aircraft Company got into production on a new bomber. "Visuals" were furnished to each section of the assembly line making a particular subassembly. In this manner workmen, foremen and officials could see what the finished assembly should look like and what should be in it. These pictures usually were nothing more than perspective drawings with the outer covering of the assembly removed, and until recently this practice was almost entirely limited to drawings of subassemblies on the production line.

Now, however, the matter of making and using visuals has been approached with an entirely different



This is how an engineer's idea looks when it is put on paper in the form of a graphic illustration for a project report. Everything is in accurate perspective. This drawing is "exploded" into the parts indicated by dotted lines. To give a complete picture another drawing is made looking at the plane from the rear

philosophy by Fleetwings, Inc. This company uses visuals for everything from the original conception, when there may be nothing more to go on than an engineer's idea, to the manuals that go out with every airplane delivered; but these visuals are much more than just perspective drawings. Briefly and roughly, they are scaled perspectives with the extreme accuracy and attention to detail characteristic of the best engineering drawings.

One of the unusual features of the way Fleetwings has developed visuals is in the use of commercial artists, who have been found much more satisfactory for the work than draftsmen. In fact, the department head, who was the original graphic illustrator, as these men are known, is John Gonzales, a former commercial artist. His department works under the general supervision of R. R. Wiese, assistant executive engineer, who developed the idea originally for the company. After considerable experience in training graphic illustrators it was found that it is much easier and quicker to teach a good commercial artist to "tighten up" to the point where he can turn out satisfactory visuals than it is to try to teach a good draftsman to "loosen up," that is, become artistic. At present, the department consists of twelve men, but by the time this issue reaches the readers there will probably be several more added.

The making of a visual comes under the heading of a craft or an art, as compared with plain drafting or drawing. This distinction should always be kept in mind, and is one of the reasons why commercial artists make better graphic illustrators than draftsmen. Another reason is that artists are trained to reproduce things so that they can be visualized in three dimensions instead of two.

After a year of using visuals, Fleetwings has found that the principal advantage lies in the saving of time in drafting and production, and the elimination of design and production difficulties before they arise. An interesting example of this occurred in the recent development of a new type plane. It so happened that engineering drawings had been made for the wing assembly before a visual was made, which is the reverse of the usual procedure now. When the visual was completed, however, it was found that the landing wheel could not be retracted into the wing because of interference with part of the armament installation and the landing gear mechanism itself. This interference did not show on the drawings. Ordinarily it would not have been discovered until the plane was built. Then changes would have had to be made in all the completed drawings and the production procedure modified. In this instance all that was necessary was to change the positions of the interfering items on the already completed drawings. Even these changes could have been avoided if the visual had been finished first.

Best results are obtained, Fleetwings officials say, if visuals are made as wash, air-brush or pen-and-ink drawings. These methods save time and produce more satisfactory results than pencil. In addition, with wash or air-brush techniques, color may be used on completed drawings to differentiate between parts or installations which might appear confusing in a black and white rendering.

In the Fleetwings graphic illustration department there are several "veterans" with the remaining personnel being what might be called assistants or trainees. The masters are fully capable of following all phases of a project through from the time an engineer gets an idea until the job is completed. They are assisted by the trainees, who usually handle the simpler parts of the job and most of the changes.

When a project to develop a new airplane model is set up one of the

master graphic illustrators is assigned to spend all of his time, if necessary, on that project along with the usual staff of engineers. As the idea is discussed and developed the illustrator makes notes and rough drawings of the general outline and principal features of the plane. These are used in the continuing discussions until the project engineer decides that the desired results have been achieved. This is the point where the design is "frozen" and finished visuals of the completed plane are prepared.

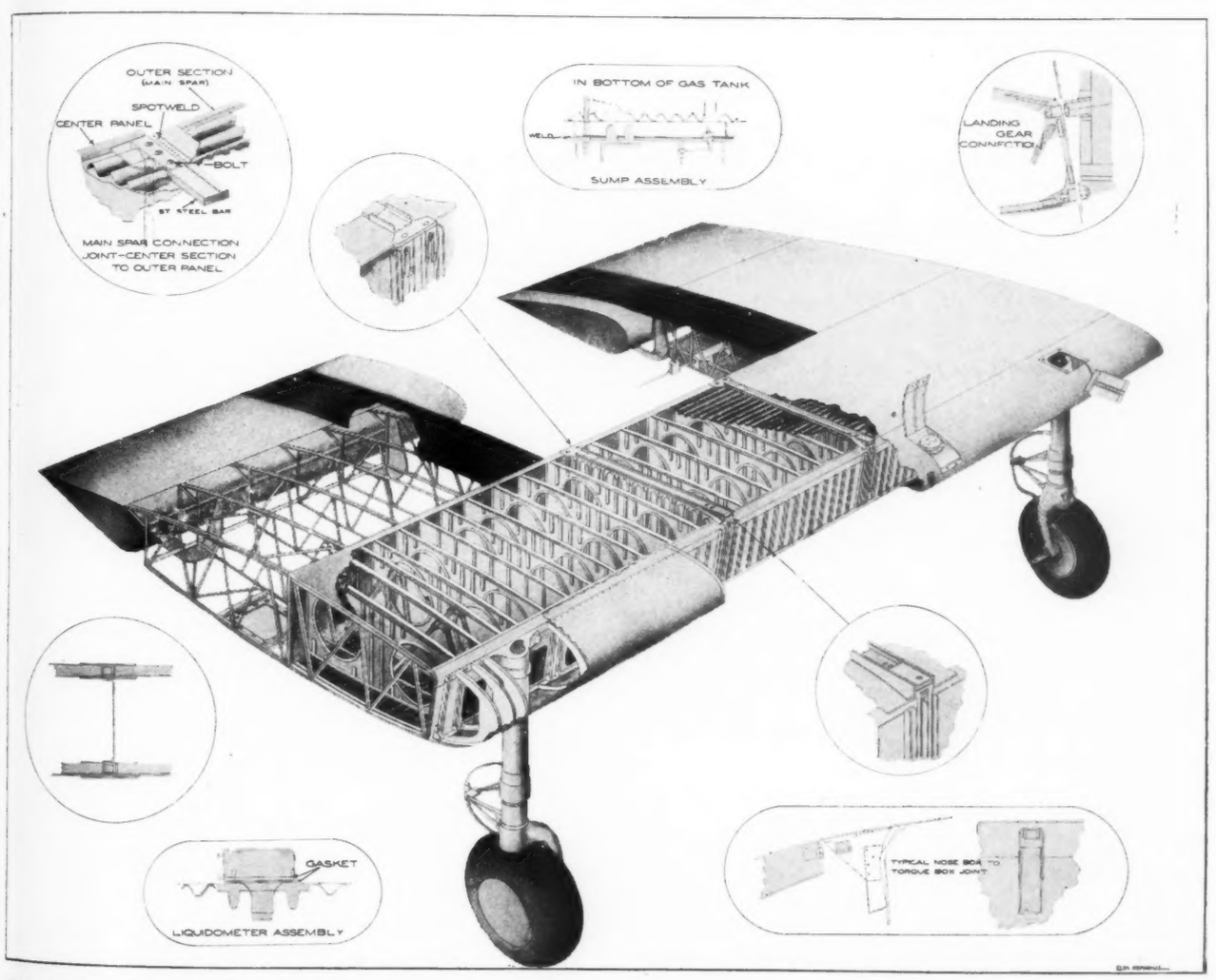
Some striking results can be achieved by this procedure. As a hypothetical case, consider a customer, who might be the sales department, the Army, Navy or any other organization which might want a quantity of planes. The project to fill the specifications is set up and when the project engineer "freezes" the design a finished picture of the plane can be shown to the customer. This picture is not just a general perspective view. It is accurate in scale and complete in every detail, including the color. The sales possibilities of visuals like these are almost limitless and the thousands of man-hours spent in making detailed drawings that will be discarded if the customer is not satisfied are avoided.

When the project engineer is ready to begin preparation of his report the visual of the finished plane is "exploded" and visuals of the sub-assemblies—wing, fuselage, tail, cowl and engine compartment, for example—and other desired features are prepared. Only overall dimensions and a few other data are available to work from. Several pictures of each assembly are made showing various arrangements of the different parts. The most satisfactory arrangement is then decided upon. In this work the outline of the assembly is traced and filled in by freehand drawing.

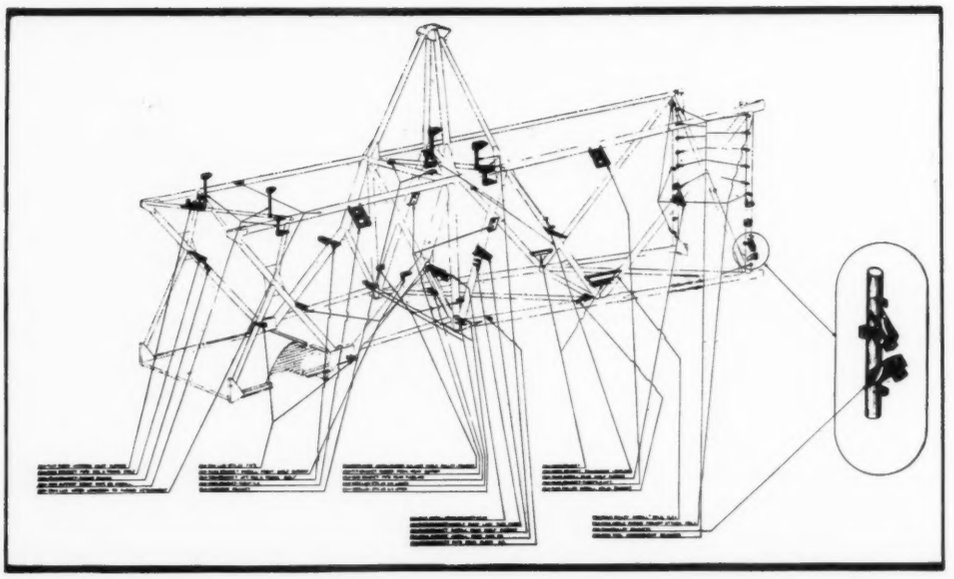
Engineering drawings are the next step and the previously prepared visuals are used by the group leaders in the drafting room to assist in the preparation of these drawings. While these are being made, graphic illustration goes to work on visuals for use in production, planning, tool design and similar departments. These are usually illustrations showing details. When a visual is completed it must be approved by the heads of all departments or functions concerned, just like any engineering drawing.

All during this process the work is geared to have the visual of an assembly or one of its parts ready at the same time as the corresponding engineering drawings. The greatest value in graphic illustrations lies in their use for visualizing what is covered by an engineering drawing, in this way helping people to interpret drawings and blueprints. Thus, timing of the release of visuals is very important for their effective use.

Next, the visuals are photostated and bound in the form of a production engineering report on that particular model plane or item. This practice makes the contents of the re-

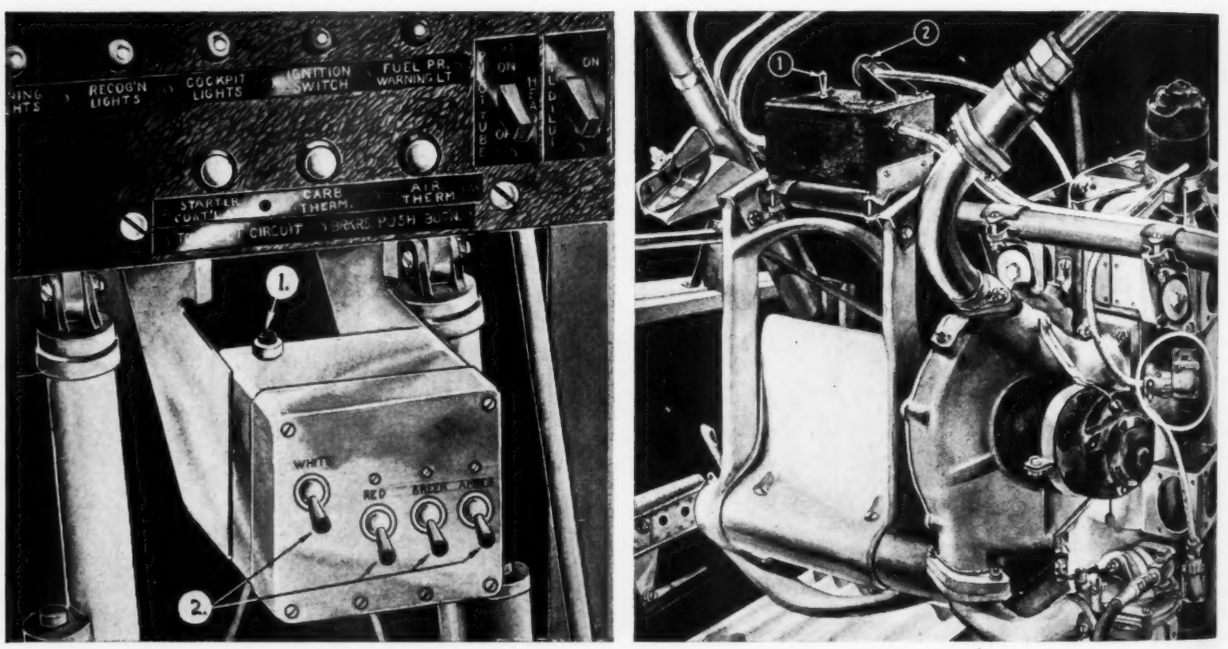


This visual gives the details of the center section of a wing and is a particularly good example of the work done by graphic illustrators. This illustration was made direct from the original to preserve the detail as much as possible.



All surface controls are shown in this installation visual. Supplementary visuals on which all part numbers are noted are made for the various components of the control system

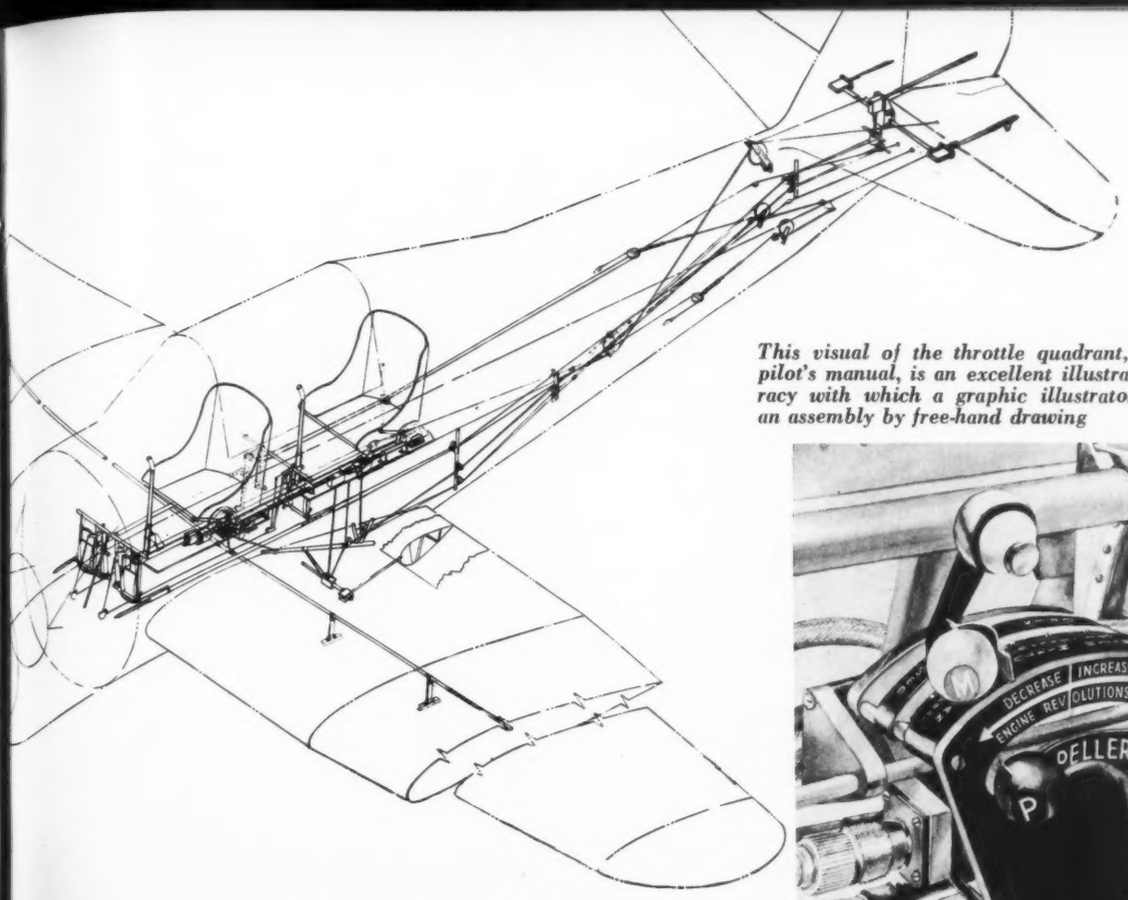
A full-scale reproduction of this visual is used in the welding section of the assembly line to make certain that all brackets and lugs are attached. The references give the numbers and titles of detail engineering drawings which give the actual dimensions and other data



(Left) Recognition light controls are explained in this visual. For drawings of this kind of equipment the graphic illustrator sits in the pilot's seat and sketches the unit as it would appear to the pilot. (Right) The cabin-heating unit is shown at the right of this illustration, with the heater controls mounted above the pedal and indicated by numbers. In the production visual of this assembly it was indicated that interference would develop if the part circled here was mounted vertically instead of horizontally, as shown. The heater manufacturer was contacted and it was found that mounting the unit horizontally would not affect the performance of the heater. Thus, this interference was remedied while the plane was still in the design stage and much time that could have been spent in redesigning was eliminated. These two illustrations are from the pilot's manual

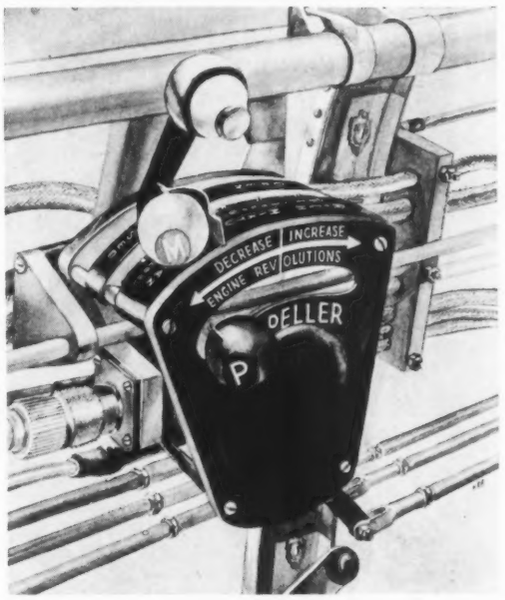
port clear to anyone, regardless of whether or not he is an engineer. Subsequent visuals can be easily added. A copy of this report goes to management and engineering executives; heads of production and tool design; planning and material control; local representatives of government agencies; project engineer, inspection, dispatching and expediting; estimating, production engineering and weights and structures departments and Wright Field. Frequent requests are received for full-size reproductions for training of ground crews and by the production department for use in the shop.

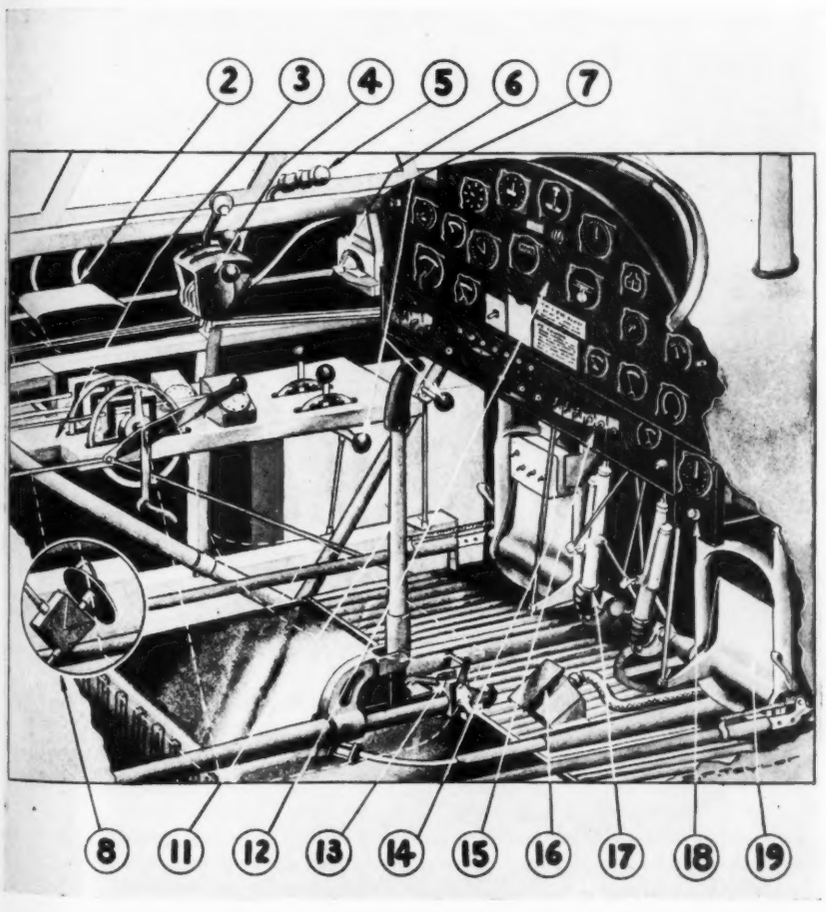
Most of the visuals which go to make up the production report have each part shown with a key number. A box in one corner lists these key numbers and the corresponding number and title of the engineering drawing covering that particular part. Sometimes, however, the drawing numbers and titles are put right on the visual in place of the key numbers. By this procedure the unnecessary distribution of blueprints is avoided, since people interested in a particular



Location of all equipment in the front section of the cockpit is shown in this visual. Numbers refer to a list where the name of the part indicated may be found. The seat is drawn in outline to indicate its relative position and that of the pilot. Notice the "artistry" put into these drawings as compared with those for the production report

This visual of the throttle quadrant, taken from the pilot's manual, is an excellent illustration of the accuracy with which a graphic illustrator can reproduce an assembly by free-hand drawing



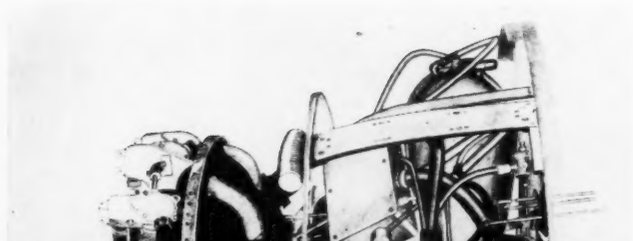


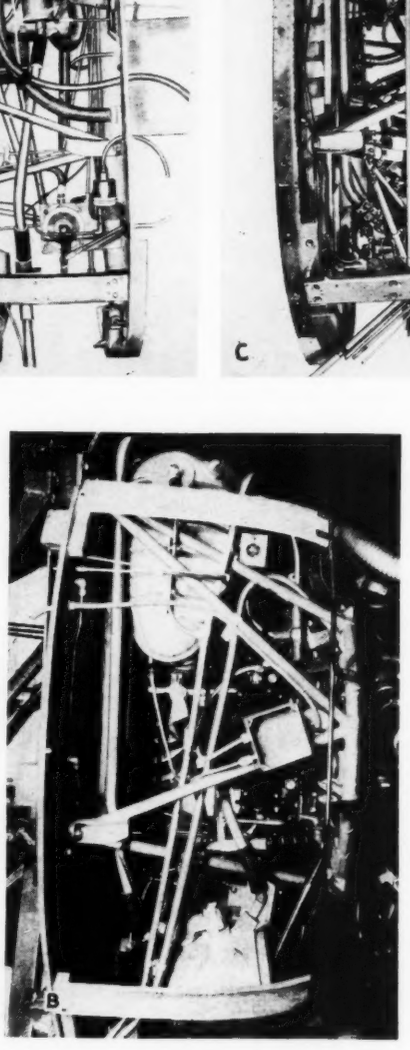
part order only blueprints covering that part.

Finally, the manuals to go with each plane are prepared. These cover flight operations, erection and maintenance and structural repairs. They consist entirely of photographs of visuals made up in wash, ink or air brush. More artistry goes into the visuals for the manuals than those for the report, which usually contains visuals done in pencil or wash with a large amount of detail. This philosophy is based on the production man working from the inside out and the service man or pilot working from the outside in.

Beginners in the Fleetwings' graphic illustration department are broken in on making changes on completed visuals, thereby familiarizing them with the company's standards and practices. Girl trainees do the lettering. Thus, the time of trained personnel is spent as much as possible on the hardest and most important work of the department.

Visuals for the manuals have been found superior to photographs for many reasons, chief of which are time and cost. A satisfactory visual can be prepared in less time and for less money than is necessary for waiting





Advantages of visuals over photographs are illustrated here. (A) Visual of the power plant installation from a production report. This is done in pencil. (B) Photograph of a mock-up of the same installation, from the opposite side. Notice the flatness of the picture. The highlights are too bright and the shadows cut out much detail that it is necessary to show. (C) Wash-drawing visual made by a graphic illustrator after the same power plant has been installed in a plane. Note here the evenness of shading and the realistic effect produced by the wash. This work is entirely freehand, yet it has the accuracy of an engineering drawing, with considerably more detail than would usually be found in such a drawing

for the plane to be finished and then taking, developing and retouching photographs. Things that are unnecessary or get in the way of making a clear picture can be left off or outlined in a visual. Unlimited tonal values can be applied on a visual, which is impossible with even the best camera equipment and photographer doing the work. Confusing highlights and shadows are eliminated on visuals and details can be as simple as desired.

Fleetwings developed graphic illustration as a result of efforts to solve a problem. There was a certain sum of money available for tools and the tooling department did not have available complete engineering drawings. In the original tooling estimate, perspective drawings of the major assemblies were provided. These were sufficiently comprehensive to show the general construction details so that. for example, it could be determined that some wing ribs could be made on the rubber press and others would be made using spot-welding jigs. From this small beginning many other uses for visuals developed in both production and engineering. The tool design department, in the meantime, carried the work further, issuing manufacturing procedure reports showing assembly methods beginning with the small details and building up step by step to final assemblies.

When it became known what the engineering department was doing for the tool designers, requests started to trickle in from other departments. Everybody wanted to see a picture of what he was working on. Even the Army asked for certain visuals for use with data on spare parts. Now visuals are distributed to almost every department in the organization.

Uses for visuals of the kind developed at Fleetwings are practically unlimited. All phases of operations offer possible applications. In this can be included assembly lines, servicing, scheduling and inspection. Other places are conferences, follow up and liaison work, training of new personnel and, last but very important, sub-contracting. Fleetwings' experience with visuals in most of these applications has become quite vast.

In sub-contracting it has been found that a visual of the assembly to be farmed out along with the usual engineering drawings will produce quicker and more satisfactory results. Recently Fleetwings let out a contract on which there were no sample parts to show the prospective subcontractor. So Fleetwings sent its own visuals of the sub-assembly along with the original blueprints and other data. In an amazingly short time the other firm found that it could make this assembly, largely because the engineers had an accurate picture of the work to be done.

When a new model airplane was put into production some time ago it was found that the first units to reach

the end of the assembly line were missing about half of the brackets and lugs for mounting various equipment and controls in the center section of the fuselage. These brackets and lugs are welded on and the crew responsible for this work could hardly help miss a few, particularly since they were called out on various installation drawings. As a result, the fuselage had to be reworked to add the remaining parts. Now there is a full-size reproduction of the visual hanging on the wall at the section of the assembly line where the work is done, showing the location of these brackets and lugs. One man stands at the chart and checks off each item as it is attached. The fuselages now reach the end of the line with all the brackets and lugs in place.

Even the purchasing department can make use of visuals to facilitate its work. Full-size reproductions of visuals can be sent out with requests for bids and suppliers will be able to estimate prices much more closely. Also, for the use of salesmen who call, visuals can be hung around the walls of the department, or manuals prepared, to enable salesmen to get a clear idea of where any of his company's products may be useful in making the assembly or machine which the buyer may want to manufacture.

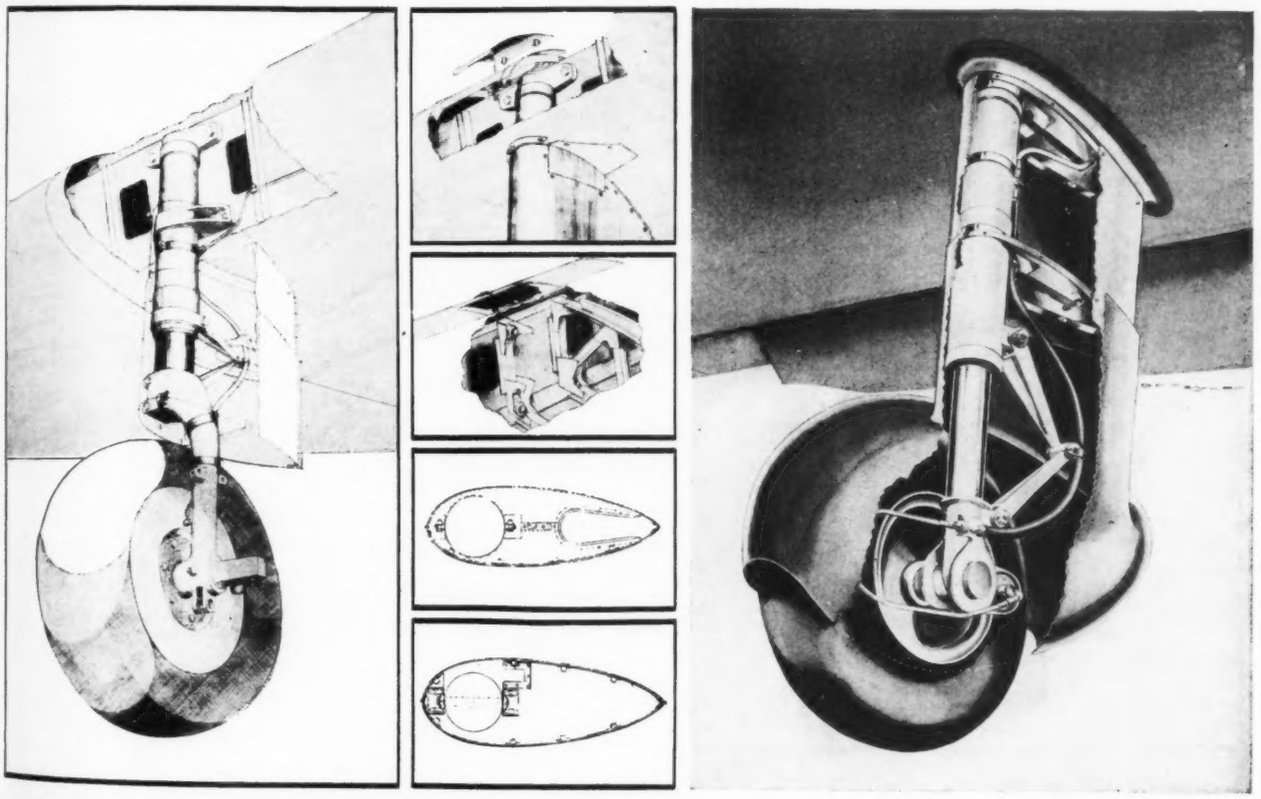
Sales, including promotion, must not be overlooked. The right kind of visual in a salesman's portfolio or in promotion literature will do more actual selling than thousands of either written or spoken words because the product will be shown accurately and completely—and much more so than the best photograph or other means of reproduction. Catalogs, too, should be considered here.

Making and using of visuals by Fleetwings, as described briefly in this article, does not indicate by any means their full development. Any designer could adapt the basic idea to his own work and that of his firm with little trouble once he appreciated the general principles underlying their preparation and use. The philosophic attitude taken toward them is very important.

To begin with, it must be realized that the best visual in the world will be a dismal failure if it does not do the job for which it was intended. The finest engineering drawings are good to look at, but they are a waste of time and money if they are used in the wrong place at the wrong time. Visuals, too, are subject to this limitation. They will not tell a person how to build an airplane, or an automobile, or a refrigerator, or anything else.

In order for any visual to be a success it must be accurate; this is more important than anything else. Right behind accuracy comes completeness. Everything must be shown down to the minutest detail. To be worth the money and time necessary to make it a visual should be so accurate and so complete that no one can criticize it, most of all an engineer. If it does not satisfy this condition then it is no better than an ordinary perspective drawing or photograph.

When all is said and done visuals are nothing more than another tool for the engineer to use to simplify, speed up or otherwise aid his work. The designer can use them most effectively, perhaps, at the moment; but those concerned with production, inspection, servicing and personnel training also can put them to good use. When they are integrated into the normal processes and functions of a manufacturing firm, such as has been done by Fleetwings, their importance and usefulness grow by leaps and bounds. For cutting costs, measured in man-hours, and making shortcuts they would seem to have more possibilities than any other single development in engineering practice for many years past.

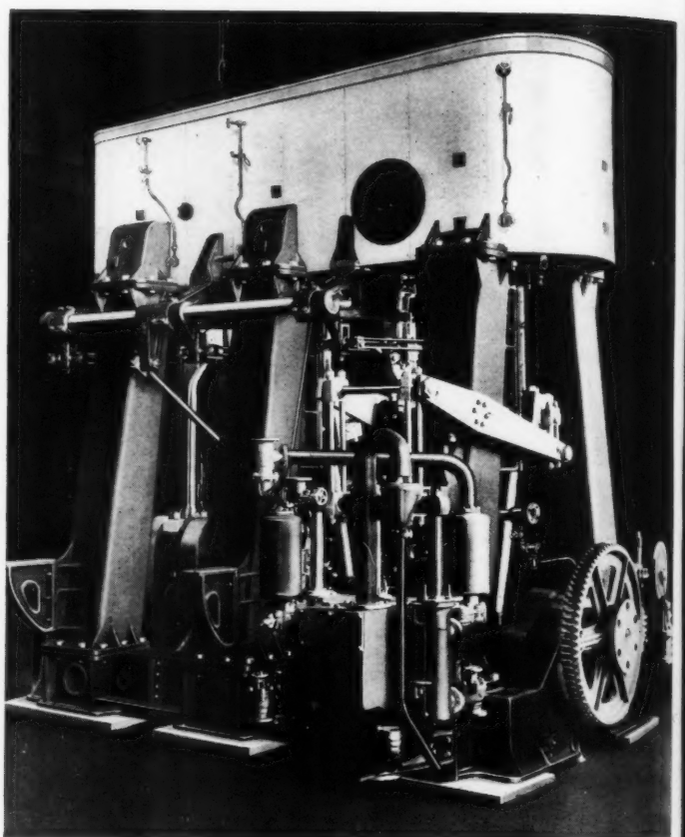


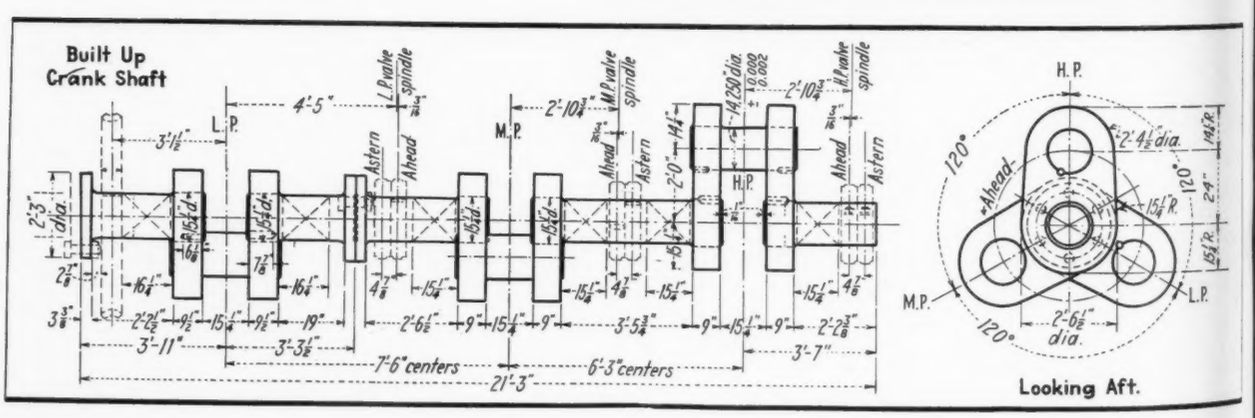
The difference between the pencil and wash processes of making visuals is graphically shown by these illustrations. At the left is a landing gear assembly and the main installation details as they were prepared for the production report. At the right is the same assembly, modified in some respects during the process of getting into production, as it was drawn for the erection and maintenance manual

WARTIME DESIGNS . . .

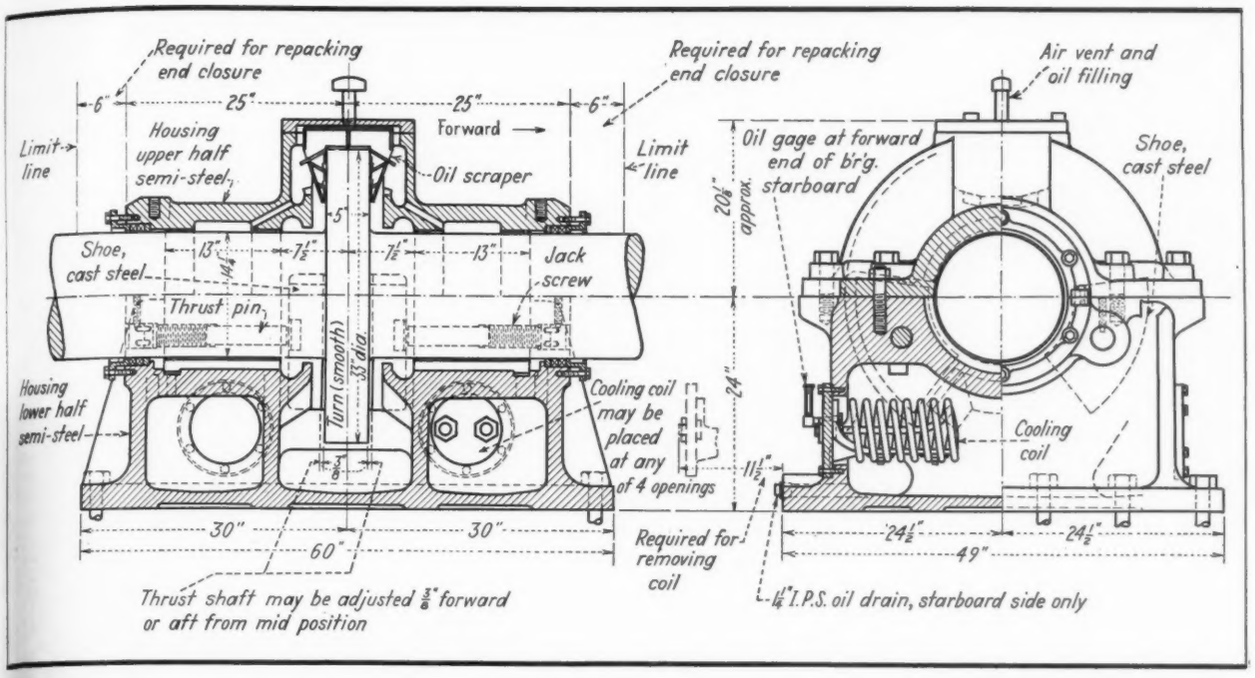
STEAM ENGINES FOR LIBERTY SHIPS

Liberty ships (Design EC2) are propelled by a single screw driven by a direct acting, condensing, 3-cylinder, triple-expansion reciprocating vertical steam engine. Basically the engine is of English design. The engineering detail work of preparing a new set of drawings, suitable for American manufacturing methods, standards and tolerances, was done by the Hooven, Owens, Rentschler Division of the General Machinery Corporation. American drawings were prepared so quickly that it was possible to complete the first engine in six months after the English drawings were received. The engineering work also involved the development of many jigs, tools and fixtures to speed the production of parts and to facilitate assembly. To eliminate duplication of effort and to hasten delivery of the engines, the detailed engine drawings and designs of special tooling were made available to other contractors.

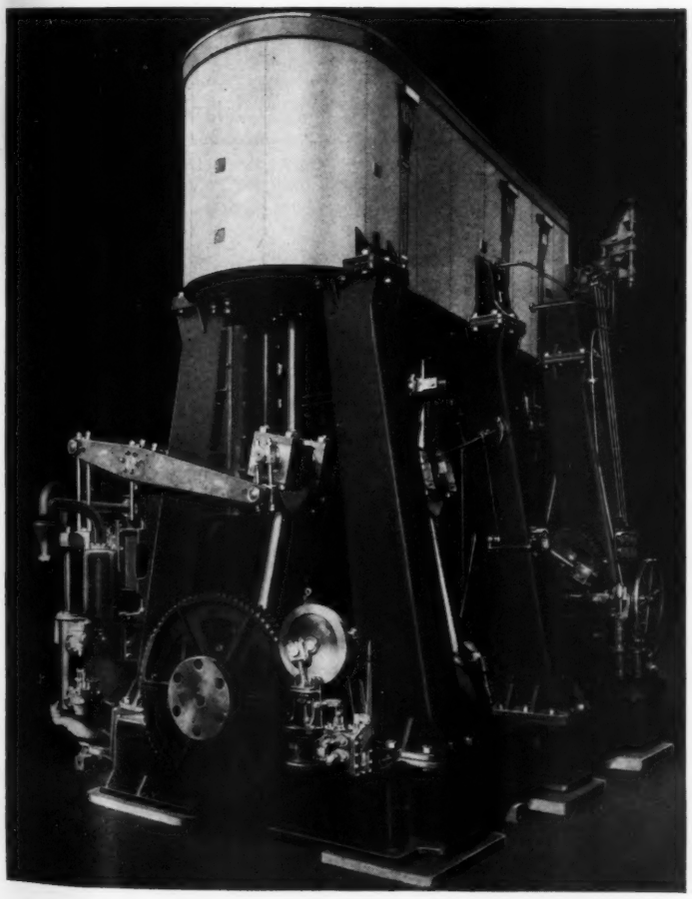




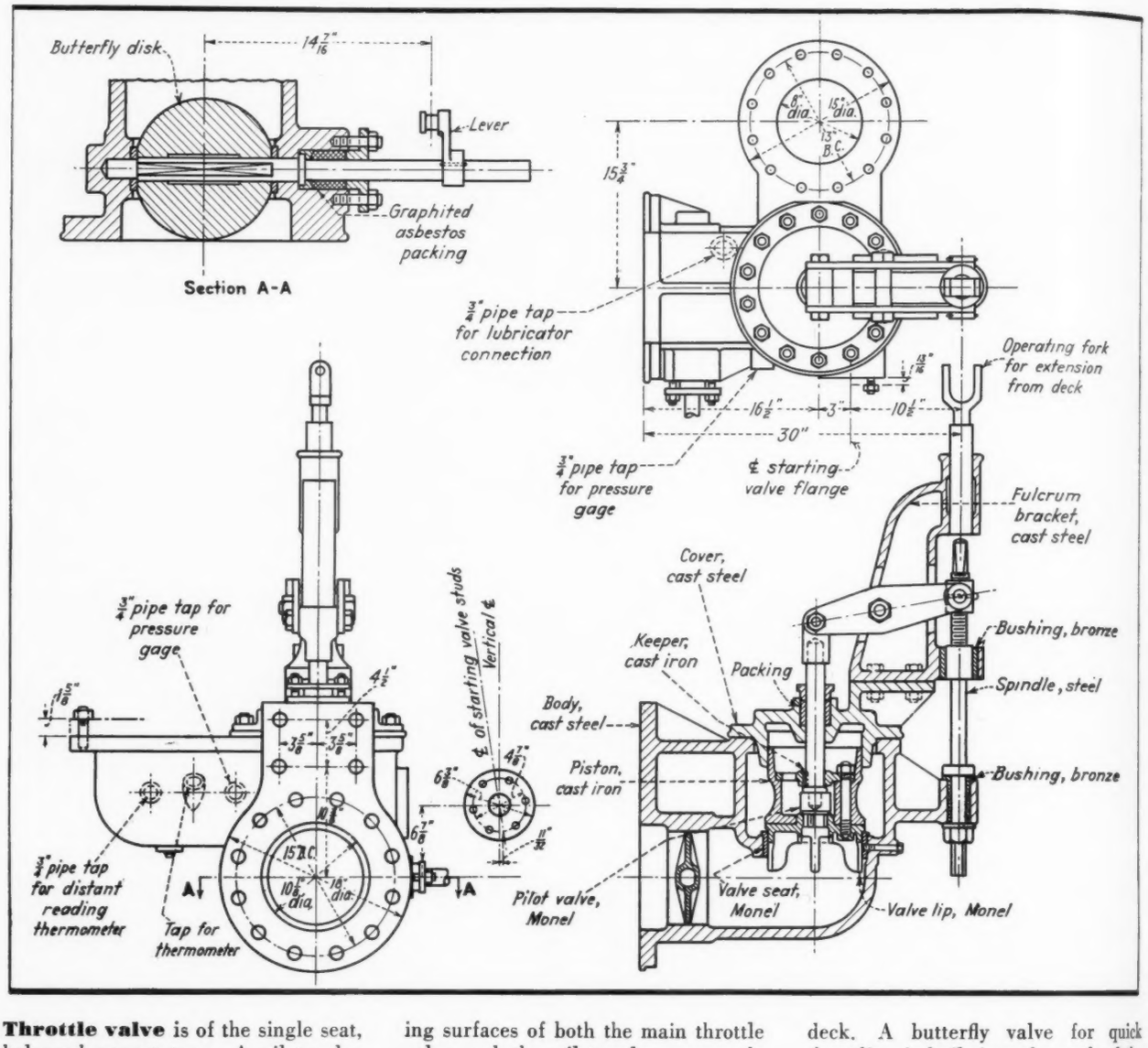
Crankshaft is of forged steel, solid forged or of the built-up type. The illustration above shows the built-up type. Crankpin and shafts are shrunk into either forged or cast-steel crankwebs. Shaft is made in two sections, the forward section making the high pressure and the medium pressure cylinders, the aft section making the low pressure cylinder. All eccentrics are bolted to the forward shaft section. Low pressure section carries the turning gear wormwheel. Coupling flanges are forged integral with the shaft and are held by fitted bolts.



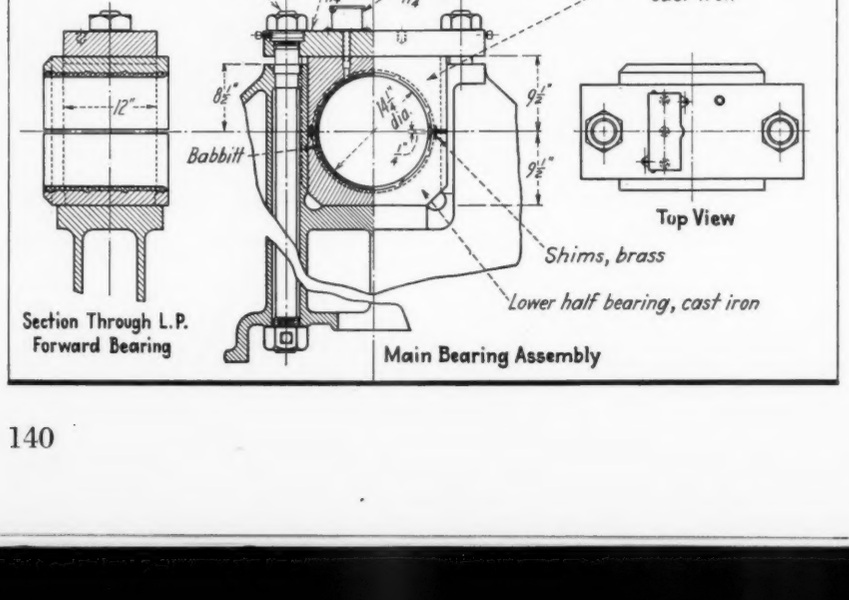
Thrust bearing. Principal parts include a semi-steel housing with two journal bearings, a thrust shaft with integral forged collar, and two pairs of thrust shoes (two shoes for ahead and two for astern thrust). Each shoe covers about 60 deg. of arc. Shoes are individually adjustable fore and aft by jack screws. Journal bearings have removable lower half shells lined with babbitt metal. Upper half bearing babbitt is cast in the housing cover, leaving large pockets for oil. Lubrication is automatic, a metal scraper riding on the collar distributes oil to the collar surfaces and the journal bearings. Ordinarily, the bearing cools itself by radiation. But, a small copper cooling coil is provided in the oil bath for emergencies. Cooling coil may be placed at anyone of four positions in lower half of housing. Ends of the bearings are sealed by stuffing boxes around the shaft.



Main engine of the Liberty ship is of the vertical, 3-cylinder, triple expansion type. Cylinders are 24½-37-70 in. dia. x 48 in. stroke, and develop 2,500 indicated hp. at 76 r.p.m. Steam gage pressure is 220 lb. per sq. in., maximum steam temperature is 450 deg. F. Engine exhausts at 26 in. vacuum to a surface condenser bolted to the back columns of the engine. Cylinder arrangement from forward to aft is high pressure, medium pressure, low pressure. High pressure cylinder is provided with liner for the piston as well as the piston valve. All cylinders are cast individually and bolted together to form a unit block. Steam chests are cast integrally with cylinders, thus eliminating inter-connecting steam pipes. High pressure cylinder is fitted with piston valve. Medium and low pressure cylinders have box-type balanced slide valves. Bedplate is continuous under the entire engine and supports the cylinders through columns. Main bearings for supporting the crankshaft are set in recesses in cross girders. Bedplate is bolted directly through chocks to the tank top. Columns are of the box-type construction. To the back columns are bolted separate crosshead guide plates and back guides. Crosshead guides are water cooled. Reversing engine is of the all-around type and is bolted to the high pressure front column. Turning engine, attached to the bedplate, is used for turning the main engine over when required for repairs or setting valves. Air pump is of the Edwards type, and is driven from the low pressure main crosshead through beams connected to the pump crosshead.



Throttle valve is of the single seat, balanced poppet type. A pilot valve is provided to relieve the pressure on the balanced piston so that valve can be opened easily. To withstand steam erosion and "wire drawing," the seating surfaces of both the main throttle valve and the pilot valve are made of Monel. Valve is operated from the platform by a handwheel; an extension is also provided so that the throttle valve can be closed from the deck. A butterfly valve for quick throttling is built into the neck of the throttle valve which extends to the high-pressure cylinder chest. Body and cover of throttle valve and fulcrum bracket are cast steel.



Main bearings. Crankshaft is supported in six bearings, each of which consists of an upper and a lower cast iron babbitted box. The boxes are fitted into flat bottom recesses formed in the cross girders of bedplate. Boxes are held in place with flat steel bearing caps, through which bolts extend to the bottom of the bedplate. Laminated shims between the upper and lower boxes are provided for taking up wear. Bearings which support the high-pressure and medium-pressure cranks are 14¼-in. dia. by 15 in. long, those at the low-pressure cranks are 14¼ in. dia. by 16 in. long. Each main bearing is wick lubricated from an oil cup fastened on the cap.

GLASS GAGES CONSERVE CRITICAL TOOL STEEL

Photo by Office of War Information

Glass gages of various types which are replacing steel ones at the Frankfort Arsenal. Ordnance Department studies and experiments indicate that up to 50 percent of the hundreds of thousands of steel gages used by manufacturers and inspectors of ordnance items eventually can be replaced by glass products. Saving of three-quarters of the man-hours of machine tool labor required for the manufacture of steel precision gages, as well as significant quantities of critical alloy tool steel, will be obtained by the use of glass gages. It is estimated that 250 tons of tool steel can be saved annually by the government arsenals alone. Cost of glass gages is half that of steel ones after molds are made. Markings on glass handles are produced by acid etching.

Photo by Office of War Information

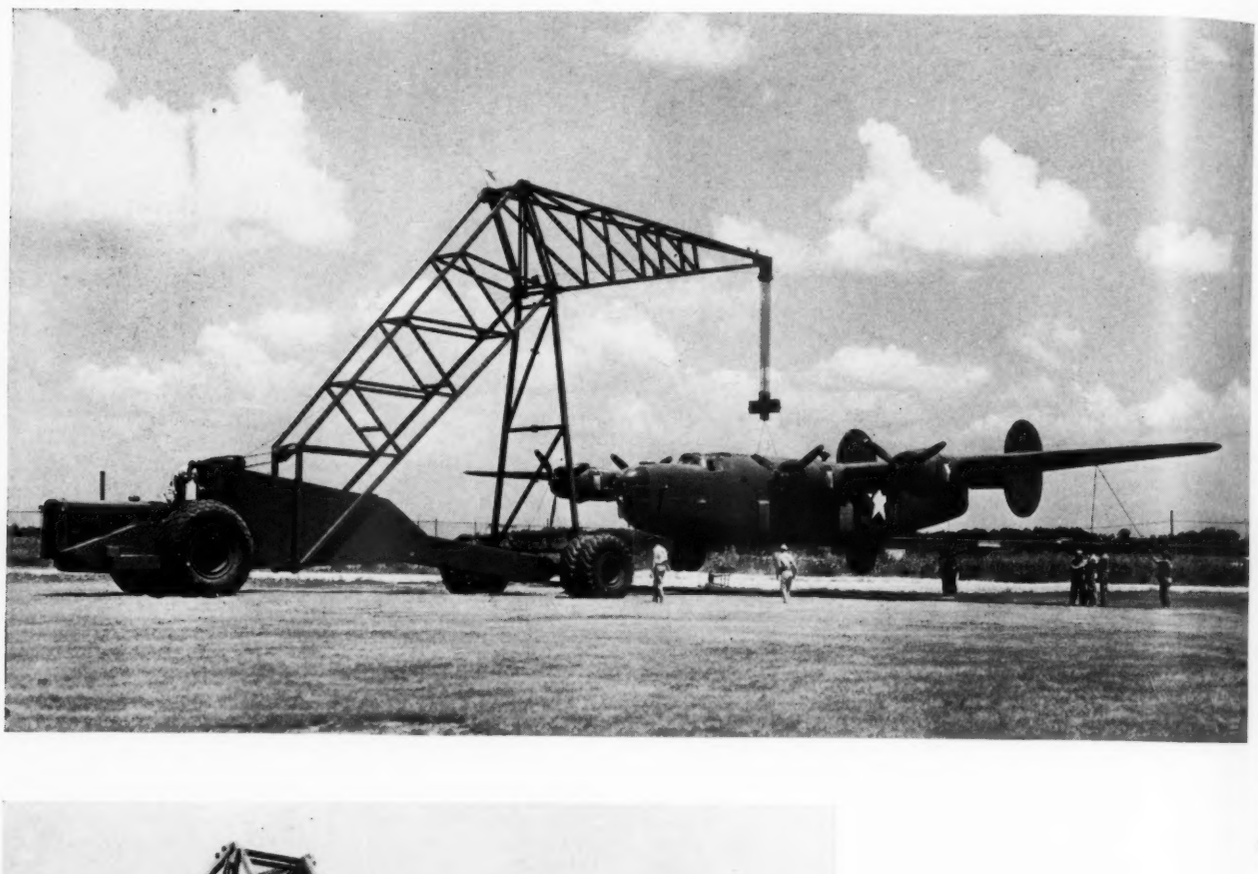
Checking outside diameter of small gear with a glass gage. Handling glass gages is easier than those of steel since glass gage is much lighter. Because there is no rust, greasing and degreasing are not necessary. Also, glass appears to have abrasive resisting qualities equal to or better than steel in many gaging applications.

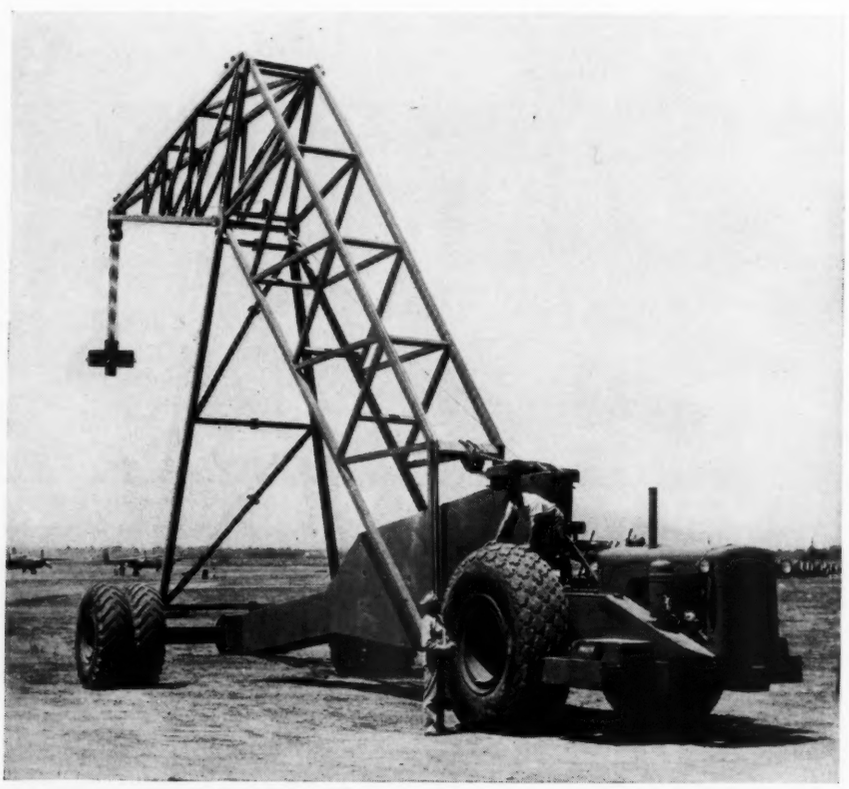
Photo by Office of War Information

Inspecting inside diameter of a metal part with glass plug gage. Where component part being inspected is very nearly the size of the gage, there is less tendency for component to seize or gall on the glass than on steel gage. Scratches on glass do not leave a burr and do not change effective size of the gage. Visibility in inspection, not always possible with steel, will tend to produce a superior product; perspiration on the hands of inspectors has no corrosive effect on the glass gage; and since thermal conductivity of glass is less than that of steel, heat transferred from the hands of inspectors to the gage will affect gaging dimensions to a less degree than it would affect gages made of steel.

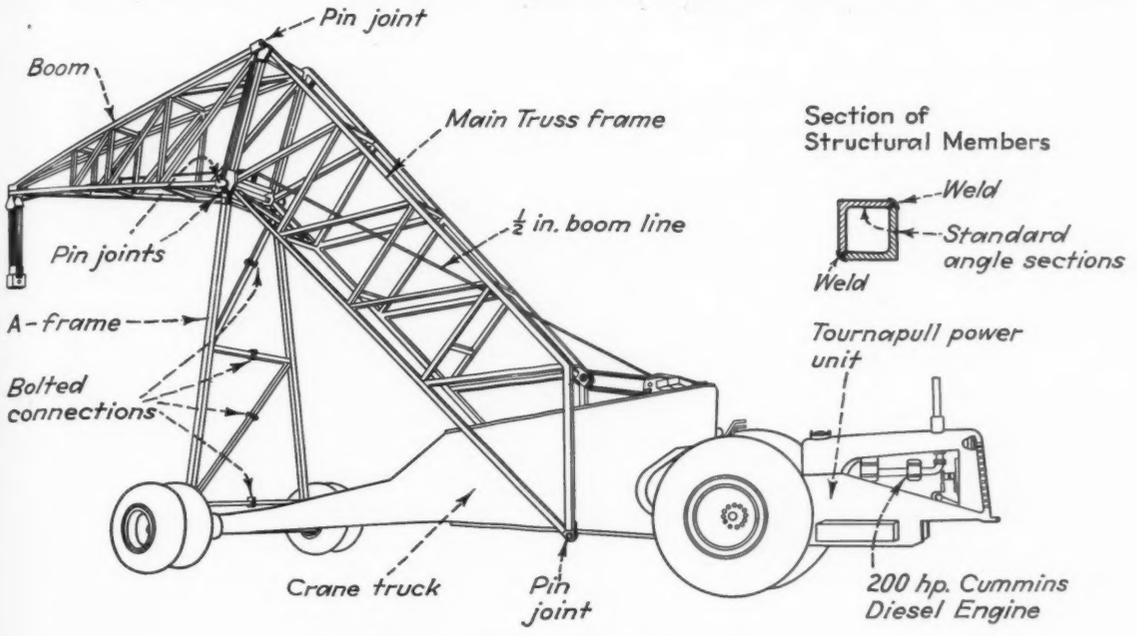
MOBILE STIFF LEG CRANE FOR AIRFIELDS

Mammoth stiff leg crane mounted on swivel trailer clears airfields of stalled or damaged aircraft. Designed by engineers of R. G. Le Tourneau, Inc., the giant crane, lifting capacity of 30 tons, is drawn by a Tournapull unit which is powered with a 200 hp. Cummins diesel engine. Crane structure consisting of welded main truss, A-frame and boom, is designed to facilitate quick assembly.





Transmission is geared for four speeds which range from 2.6 m.p.h. in low to 15.0 m.p.h. in high gear. Hydraulic brakes are provided for braking and chocking the front wheels. Tournapull unit has two (30x40) 28 tires. Crane is equipped with four (24x32) 36 tires. One wheel with tire weighs 2 tons. Crane truck carries about 10 tons of sand for ballast. Lift of crane when in upright position is 33 ft. 8 in., reach is 35 ft. Overall dimensions of crane and tractive unit are; length 87 ft. 6-¾ in., width 23 ft., height 38 ft. 10 in. Boom structure is 44 ft. long. Distance from axle to drawbar is 36 ft. Weight of crane and combined units is approximately 65 tons.



30 TON CRANE FOR AIRFIELDS

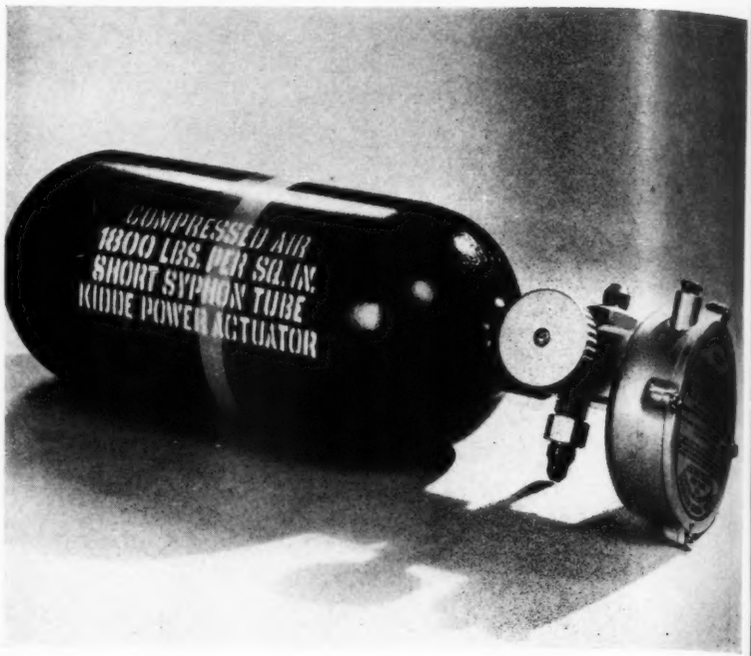
Stiff leg A-frame, boom and main frame truss are separate welded structures. Each of which has chords, struts and cross-ties of rectangular box section made by welding together longitudinally the edges of standard angle sections. Pin joints are used to connect the forward ends of main truss to the crane truck body, the bottom ends of stiff leg A-frame to the axle, the top ends of stiff leg A-frame to main truss, and the boom to main truss. Front end of main truss is, of course, open to straddle the truck body. Lower cross-ties of truss are arranged in ascending heights from rear to front so that in assembly the truck body can be backed into the open front end of the truss, the truss first being lifted with jacks at the first panel connection to clear the axle, then after axle is cleared jacks are placed at front end of truss to raise it high enough to make connection with truck as it is backed in further. After pin connection on under side of truck body is made, the reeved cable sheave box is then fastened to upper front cross-tie of truss. The truss can then be swung up and held to serve as a stiff leg for lifting the A-frame and boom structures into position for assembly. Because of its extreme width, the A-frame is made in two pieces so that it can be carried in a freight car, square flanges welded to the cross ties and diagonals of the frame are provided to make bolted connections.

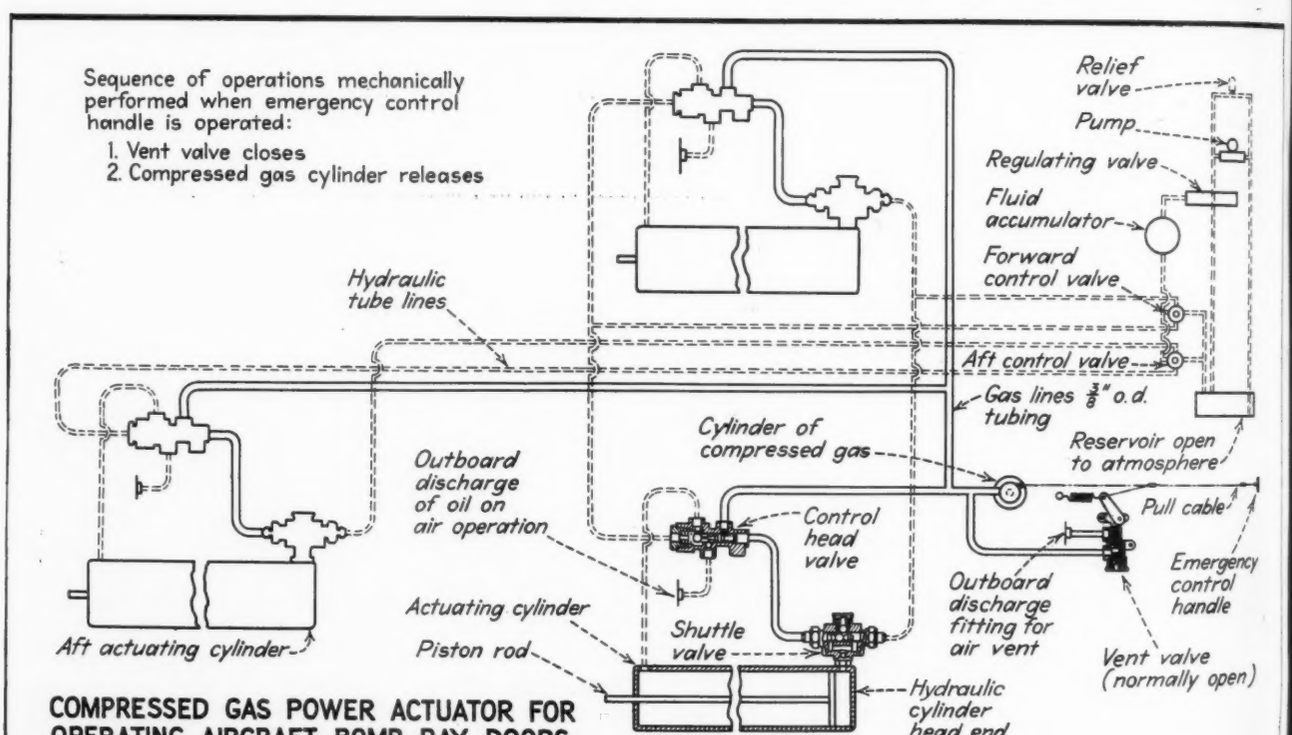
PILOT SEATS MADE OF NON-STRATEGIC MATERIALS

Pilot seats for training, pursuit and bombing aircraft are made of plastic impregnated fabric and wood to save strategic materials. Mounting brackets, shoulder harness and adjusting fittings are the only metal parts used to make the aircraft seat designed by the Harvil Corporation. In addition to the advantage of saving strategic materials, and its light weight, the seat requires little tooling to manufacture. The seat can be easily and economically adapted to various designs and standards. No heat or pressure is required in fabrication, a feature that makes repairs in the field easy and practical. The seat weighs no more than an equivalent metal structure. Several types are being made. Where installation requires deviations from standard design they can be easily made.

COMPRESSED GAS ACTUATOR FOR AIRCRAFT

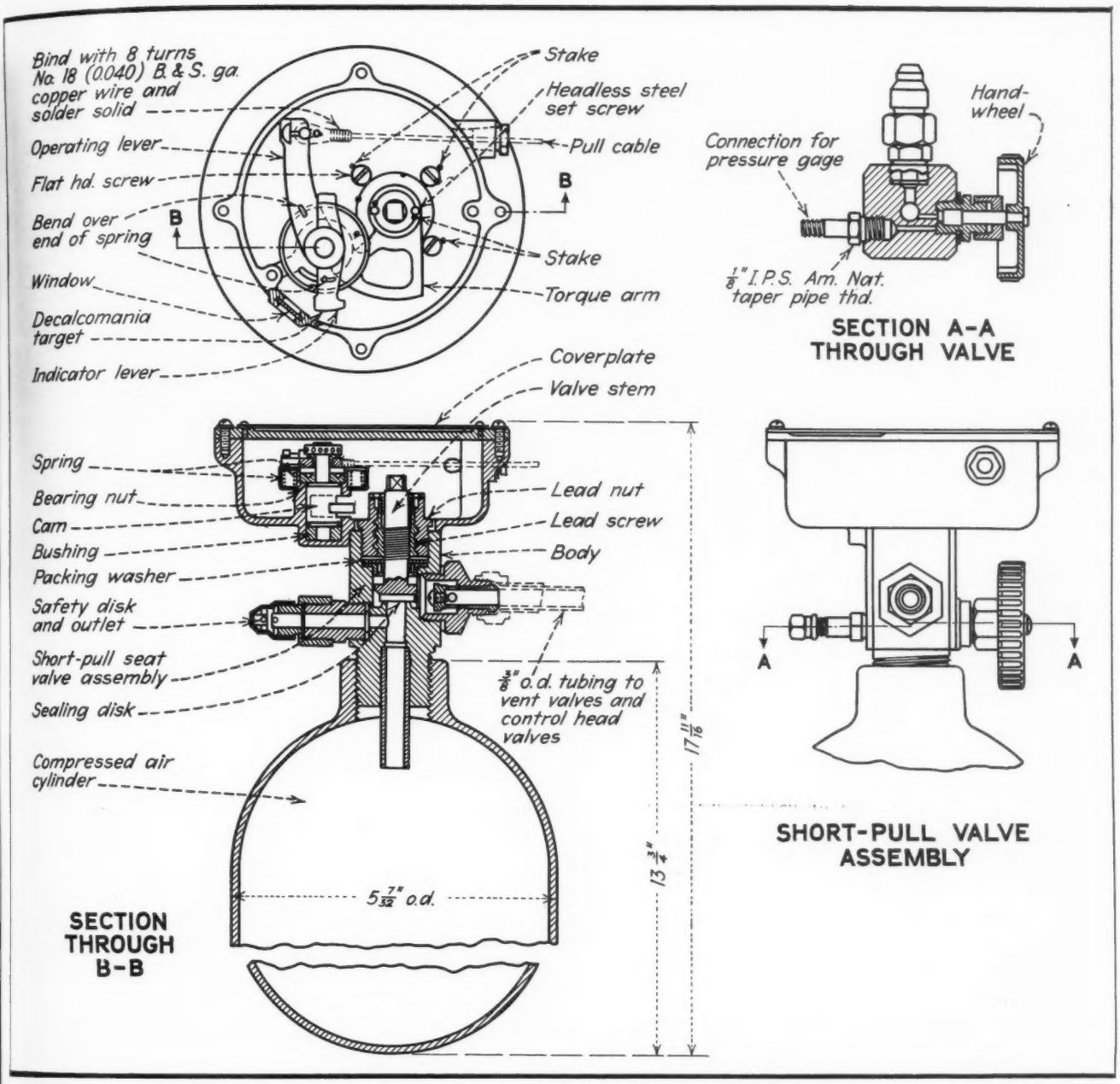
Carbon dioxide gas, which has long long been in use to inflate rubber rafts and life-vests, as well as for extinguishing airplane, tank, marine and industrial fires, has recently been harnessed as a source of emergency power through a new development by engineers of Walter Kidde & Company. The power actuator system is a steel bottle filled with liquid carbon dioxide or compressed air with suitable valves that can be connected to the regular hydraulic systems used for opening bomb bay doors, for lowering retractable landing gear and for applying brakes of aircraft. If the hydraulic system fails or is damaged by anti-aircraft or machine gun fire in combat, the compressed gas can be released into system to operate pistons.





COMPRESSED GAS POWER ACTUATOR FOR OPERATING AIRCRAFT BOMB BAY DOORS

Schematic layout indicating how compressed gas power actuator is arranged and connected to an aircraft hydraulic system for opening bomb bay doors quickly in an emergency. Operation is accomplished by pulling an emergency control handle which is connected by cable to a short-pull seat valve fitted to top of compressed gas cylinder. Cable is also connected to a normally open vent valve installed in a branch from the discharge line of the gas cylinder. When emergency control handle is pulled, the cable closes the vent valve and releases the compressed gas in the cylinder. Gas then flows to a control head valve at each hydraulic cylinder and closes the hydraulic line leading to the rod end of the cylinder. Gas then flows through the control head valves to shuttle valves, one at the head end of each hydraulic cylinder. In each shuttle valve the pressure of the gas moves a spool valve that closes the hydraulic line and admits gas into the head ends of the respective hydraulic cylinders. As the expanding gas drives the piston forward, the oil on the downstream side of the piston is dumped outboard or may be returned to reservoir.

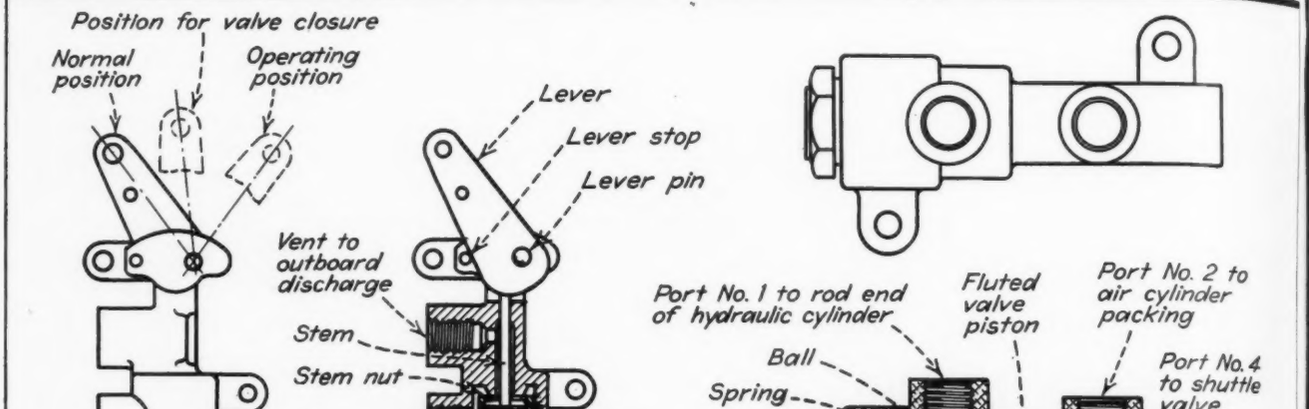


Short-pull seat valve, permanently mounted in cylinder, retains compressed air or gas at pressures up to 2,000 lb. per sq. in. A safety disk and safety outlet are provided at side of valve, these automatically release gas to atmosphere in the event that pressure in cylinder should become excessive because of high temperature or overcharging of cylinder. An outlet connection is also provided for an indicating pressure gage. Turning handwheel admits cylinder pressure to gage when connected, and is also used when filling cylinder through Schrader type connection.

Seat type cylinder valve opens when the valve stem moves upward. Valve stem is threaded and screws into a lead-screw which mates with a short lead-nut. Lead-nut is screwed firmly into the valve body and is then locked to prevent turning. In order to avoid self-locking, the lead-screw is provided externally with a left-hand fast lead Acme thread. Also because of the fast lead, the vertical force applied by gas pressure on the ends of lead-screw and valve stem tends to turn and advance lead-screw upwards in a clockwise direction. A torque arm rigidly keyed to the lead-screw is normally prevented from rotating by a cam. The lower end of cam is slotted so that when the cam is rotated the torque arm is free to move through the slot. Upper end of cam, which projects through a bearing nut, mates with an indicator lever and also an operating lever to which pull cable is attached. The indicator lever is rigidly pinned to cam, but the operating lever floats freely on the cam. A right-angled projection on the indicator lever normally rests against the edge of operating lever so that any forward turning motion of operating lever is transmitted to the indicator lever.

Operation of pull cable by the pilot in an emergency will, through this assembly, rotate the cam and thus remove constraint on torque arm and permit the air pressure to rotate and raise the lead-screw, thus opening a passage which permits compressed air in cylinder to flow both to vent valve and to control head valves.

When valve has operated, a black target on a yellow background is visible through a small window in the valve casing.



VENT VALVE

SECTION THROUGH VENT VALVE

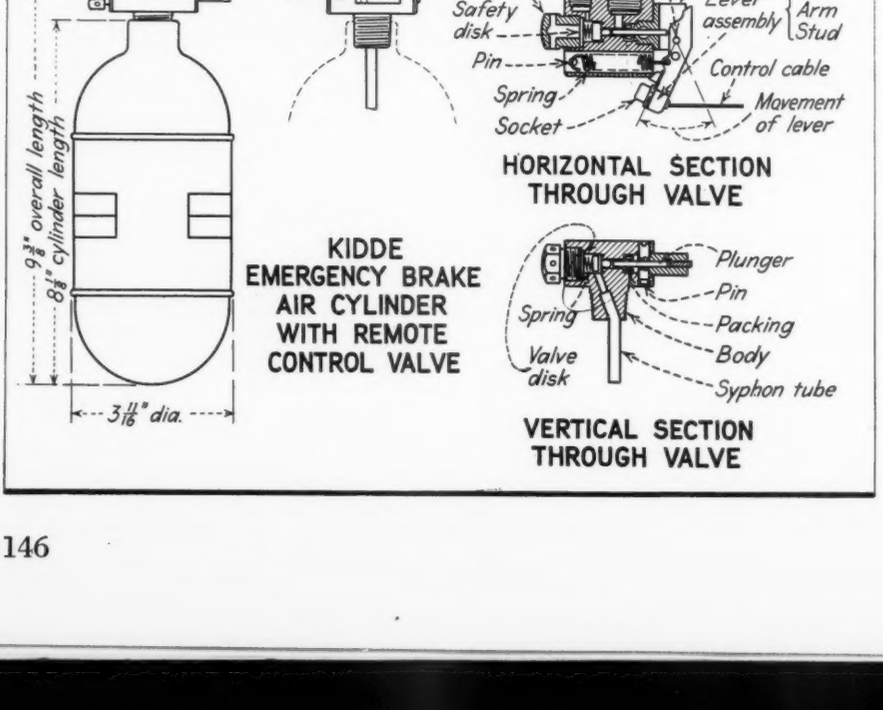
CONTROL HEAD VALVE

Vent valve is installed for the purpose of venting the air lines to enable the aircraft main hydraulic system to return the bomb bay doors to their closed position after operation of the compressed gas power actuator. During operation of the actuator, the vent valve is closed thus preventing loss of gas pressure to outboard discharge. As shown in the illustration the valve is in the normally open position, in which the spring loaded cam lever depresses the stem and holds the valve disk off the seat.

In actual operation the cam lever is pulled to the right thus permitting the stem to be pushed up by the stem spring and gas pressure to seat the valve.

Control head valve is installed for the purpose of connecting power actuator system with the main hydraulic system and to enable independent operation of either system. In operation gas enters Port No. 2 and passes through Port No. 4, thence to the shuttle valve on the hydraulic cylinder. Simultaneously the fluted valve piston is moved to the left, thereby seating the ball against the seat which closes the hydraulic supply line connected to Port No. 3. This action also enables oil from the hydraulic cylinder connected to Port No. 1 to pass through valve to Port No. 5, then discharge outboard.

After operation, the ball is returned by a spring to normal position against the opposite seat to permit the closing of the bomb bay doors with the hydraulic system. Gas vented from head end of hydraulic cylinders enters Port No. 4 and passes through Port No. 2, then to outboard discharge through vent valve, which has been reset to normal open position.



KIDDE EMERGENCY BRAKE AIR CYLINDER WITH REMOTE CONTROL VALVE

HORIZONTAL SECTION THROUGH VALVE

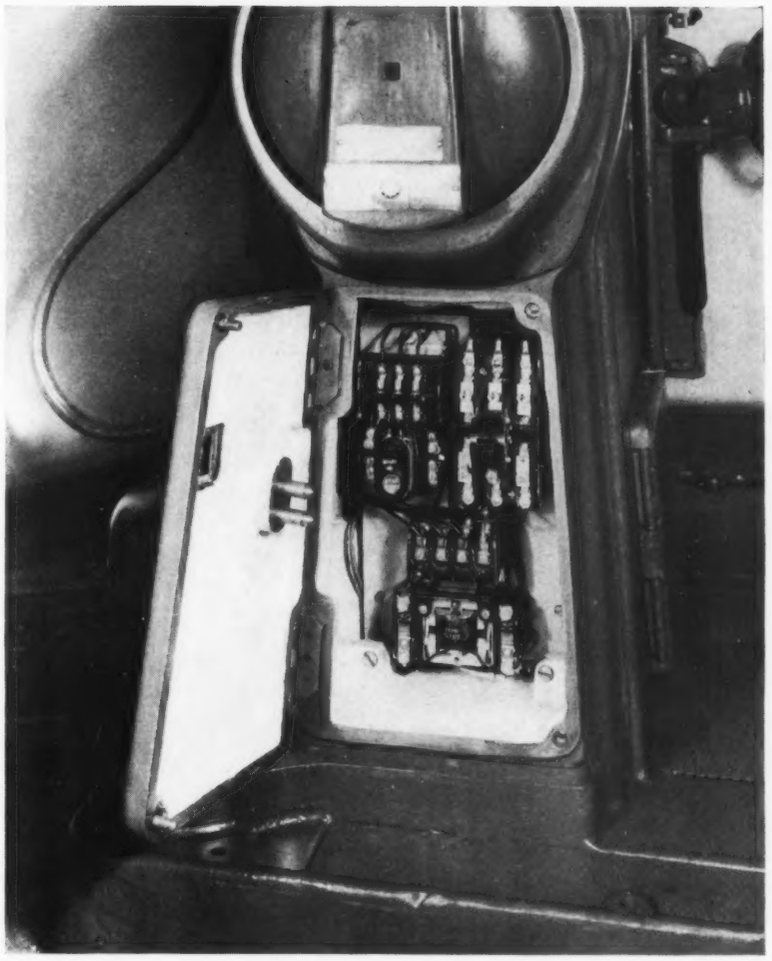
VERTICAL SECTION THROUGH VALVE

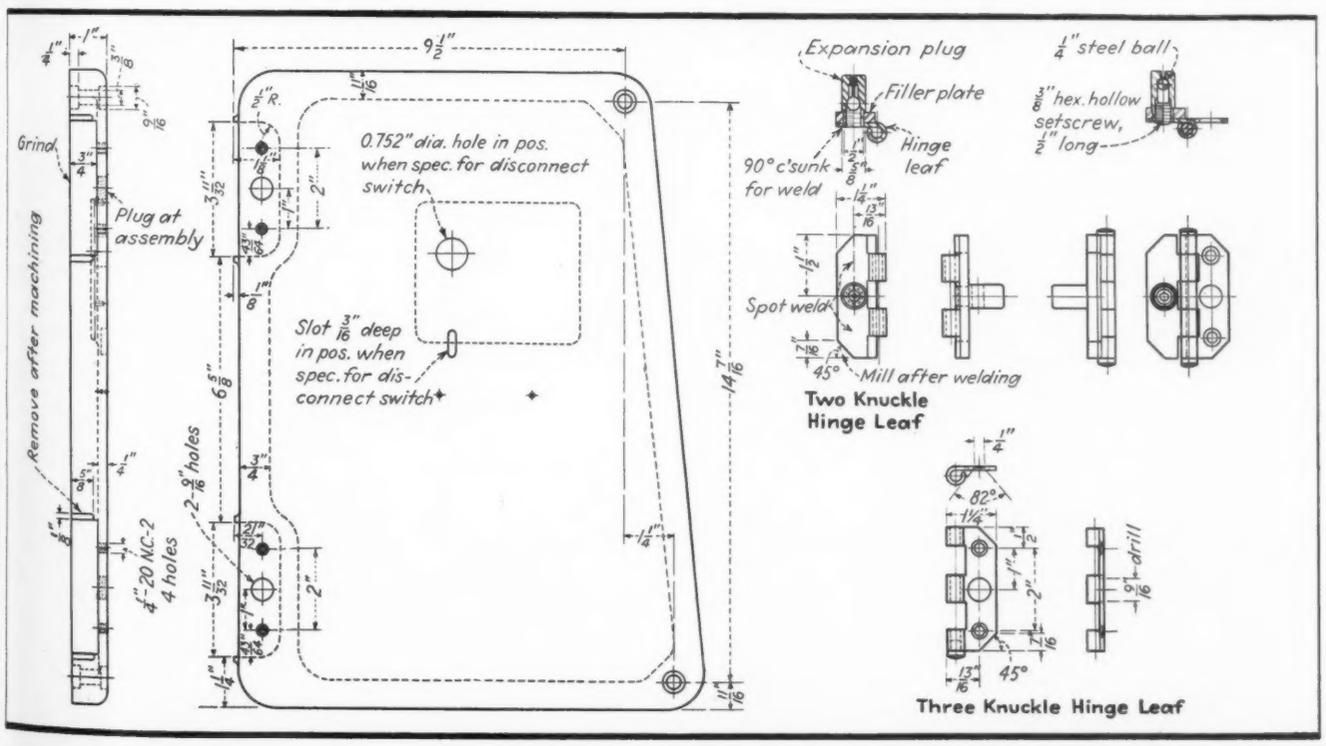
Gas or air cylinder with remote control valve for emergency operation of aircraft brakes. The remote control valve is permanently mounted in the mouth of cylinder, and retains the charge in the bottle at working pressures up to 2,000 lb. per sq. in. The gas in the cylinder is released into the connected brake supply line by simply pulling the emergency control cable which is attached to the valve lever. This operation moves the lever assembly in a manner so that the plunger is pushed into the valve body, thereby unseating the valve disk thus opening a path for the compressed air to flow from the cylinder to the supply line that actuates the brakes. The remote control valve is provided with a safety disk and safety outlet, so that the gas is automatically released to atmosphere should the pressure in the cylinder become excessive because of exposure to high temperature.

SELF-ALIGNING DOOR HINGE SAVES ASSEMBLY TIME

Door hinge designed to reduce drilling and tapping operations as well as fitting and assembly time. Original design was made by engineers of the Brown & Sharpe Manufacturing Company, the hinge has been adopted by a number of other machine builders. Only one plain drilled hole is required in the machine frame to attach hinge. Alignment and adjustment of the door is done easily and quickly.

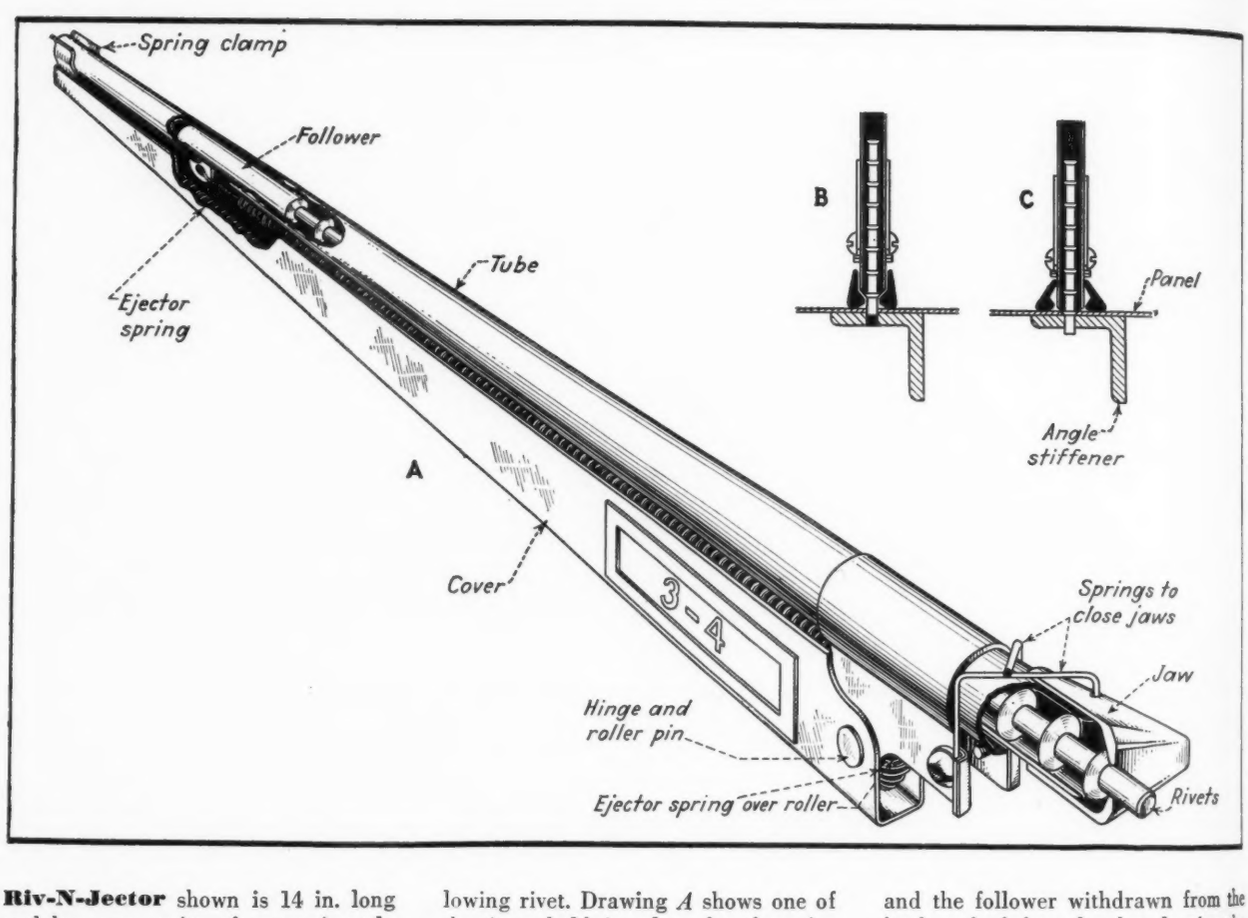
One leaf of an ordinary butt hinge is attached to the door by machine screws, or by welding if the door is fabricated. The other leaf has a filler plate welded to the back in order to bring it out to the correct position. A drilled hole through the filler plate and leaf receives an expansion stud, which after insertion is welded to the leaf. The expansion stud is drilled through its length with a stepped hole, tapped at the front end to receive a set screw, under which is a steel ball. The back end of the expansion stud is slotted longitudinally with a saw-cut. During assembly of door to frame, the expansion stud is inserted in a plain drilled hole in the machine frame and the set screw tightened, this action forces the steel ball against a tapered seat causing the split end of the stud to spread and lock the hinge to the machine frame. The illustration is a rear view of a milling machine which shows the hinge in an open position on the rear door. On the right side of the machine is a closed door with a hinge that "floats" the door into position against an unmachined surface.





AUTOMATIC TOOL SIMPLIFIES RIVET HANDLING

Faced with workers individually handling each rivet in aircraft assemblies, calling for hundreds of thousands of rivets, the Research Division of the Murray Corporation of America undertook the task of inventing and developing tools to simplify and expedite rivet handling operations. This research activity resulted in designing and patenting the Murray Riv-N-Jector, now manufactured by the Cleveland Pneumatic Tool Company under an exclusive licensing agreement. The Riv-N-Jector not only increased production, but also eliminated the tedious hand operation of inserting rivets in aircraft assembly. Savings were also realized in the elimination of waste rivets, dropped or spilled upon the floor. Time studies run with a number of inexperienced workers showed material savings between 70 and 80 percent, with a saving in labor ranging from 25 to 35 percent over the hand method of inserting rivets.



Riv-N-Jector shown is 14 in. long and has a capacity of approximately 65 rivets. When projecting rivet is placed in the hole and the tool is pressed against the work, the two jaws open and release the rivet, which is immediately replaced by another, ready for the next operation. In drawing *A*, one jaw of the Riv-N-Jector has been removed to show the position of the rivet at the injection end of the tool, and a portion cut away at the small end to show the spring and follower arrangement. Cross-section *B* shows the leading rivet extending out from the jaws ready for injection. Cross-section *C* shows the tool pressed against the work with the jaws open releasing the first rivet into the hole and automatically ejecting the following rivet. Drawing *A* shows one of the jaws held in place by the wire spring.

Fastened inside to the small end of the cover is an ejector spring that extends around a roller and is then reeved back to connect with a lip on the follower which protrudes through a slot in the tube. Therefore, when the jaws open a rivet is automatically ejected into the hole by means of the follower. When pressure of the tool against the work is released, the jaws are immediately closed by wire springs. Jaw end of cover is hinged to the tube and bracket assembly with a pin. The small end of cover is held to the tube with spring clip clamps. To load the Riv-N-Jector the cover is swung open from the spring clamp and the follower withdrawn from the back end of the tube thus leaving the tube open to receive a charge of rivets. An automatic loader has also been developed for filling the tube with a measured quantity of rivets. After loading the follower is put back in the tube and the cover closed. The automatic loader eliminates the necessity of supplying boxes of rivets to the production line. Riv-N-Jectors are designed for handling $\frac{3}{32}$, $\frac{1}{8}$, and $\frac{5}{32}$ in. rivets with different style heads and lengths. A removable identification card showing the size and length of the rivets is held in a small detachable frame on the side of the cover, so that the operator can readily identify and check the size of the rivets in a loaded tube.

Strategic materials and processes have almost entirely eliminated in this Ryan PT-25 plastic-bonded plywood trainer

Plywood Design Practice For Maximum Strength

Designing in plywood and glue has many things in common with designing with steel and other metals joined by welding but its contrasts are most striking to the design engineer. The following discussion and illustrations show many of the kinks that are now commonplace with designers of plywood aircraft. Since they are used where greatest efficiency in low weight, high strength construction are essential, they can be safely applied to any other type of structures or parts.

USE of wood and plywood in mechanical design was losing ground prior to the war and their applications were largely confined to furniture and building structures. Greater familiarity of the engineering profession with metals and better organization of the producers of metals had much to do with this condition. Under the stimulus of war economy, however, the inability to obtain sufficient metals to fill military and civilian requirements brought to the front improvements in the design of wood structures and in methods of computing stresses. These enable wood constructions to be engineered with an efficiency at least approaching that which engineers are accustomed to apply to steel or alminum structures.

Improved bonding materials in plywoods, improved methods of manufacturing plywoods, improved glues or adhesives for joining wooden members of a structure, and the development of high density plywoods by compression and impregnation with new plastic or resin binders have all had a part in new achievements with wood and plywoods. Learning to design plywood structures has as many problems as designing in steel and cast iron. Various types of woods and plywoods have as many different properties as the infinite number of possible alloys. However, it is beyond the scope of this article to discuss the differences between metals and woods or even between different woods.

Common woods or plywoods used in aircraft are American beech, sweet or yellow birch, and hard maple. These are the high density woods. Their greatest value is in resistance to abrasion and high strength for fastenings. Medium density woods are recommended for plywoods to be steamed and bent into permanent molded shapes. Ten or a dozen species of woods have been found suitable. A third, low density group of woods are recommended principally for core stock and cross banding. However, where high bending strength or freedom from buckling at minimum weight is desired, plywood made from the woods of this group are also recommended.

A fourth class might be mentioned: the compressed impregnated plywoods which were developed primarily for airplane propeller stock but which also have some applications in plywood construction where high strength is necessary. This material has the drawback of being extremely difficult to glue but certain types have been developed with natural wood surfaces which make satisfactory glued joints, or the surface may be roughened by sandpaper, sand-blasting, or other

means. The hard woods of the first named group are relatively difficult to glue also and this is a factor to be considered in selecting a wood for a given purpose.

From a maintenance standpoint it is desirable to use only standard plywoods for design. Properties of a fairly extensive variety of such plywoods have been tabulated for convenience of engineers. These include plywoods consisting of 3 to 9 plies in which thicknesses vary from 0.01 to 0.1 in. and overall thicknesses range from 3/32 to 5/8 in. Grain directions of adjacent plies are at right angles in all of these plywoods.

The strength of glue joints depends to a large extent upon the type of glue used and the technique of application. No universal standard of gluing has been adopted. Both casein and resin base glues are being employed and both classes may be applied by hot and cold setting methods. In careful design eccentric loading and tension components are avoided. End grain glue joints are weak and must be given additional strength by the use of corner blocks or gussets, as shown in accompanying illustrations. Glue joints are best in shear and can be used for all joints except those in which loads are concentrated, where there are cleavage loads or other factors.

In joining dissimilar materials, such as metal and wood, consideration should be given to designing for equal deformations under load and for uniform distribution of loads among bolts or throughout the joint. This may be approximated by tapering in such manner that the ratios of average stress in each material to moduli of elasticity are equal.

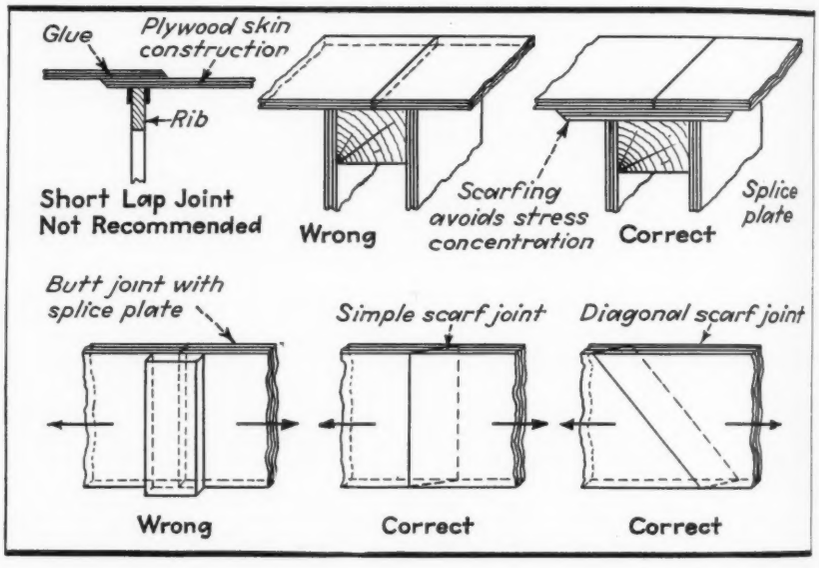
A number of proper and improper methods for designing plywood joints and for reinforcing plywood members are illustrated here. These may be applicable to aircraft, bus or truck bodies, or any other applications where the strength of the material must be employed most efficiently.

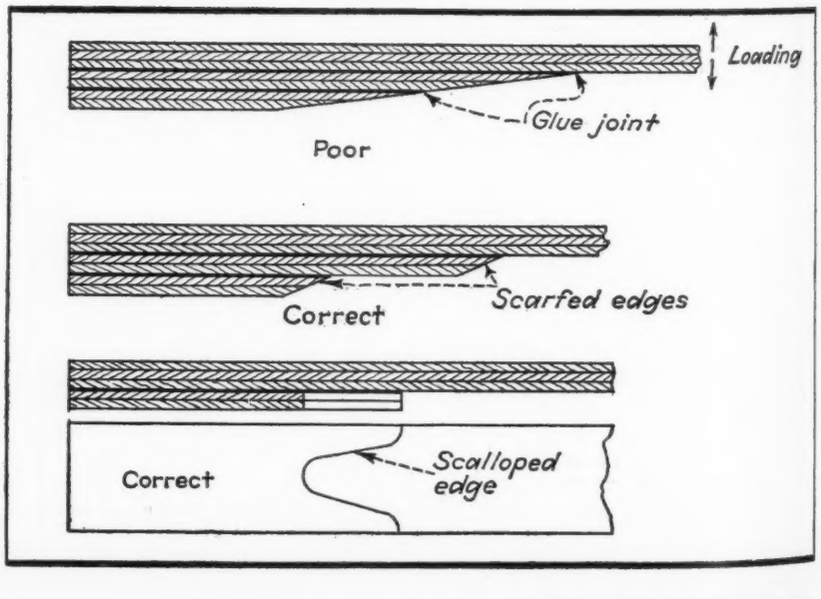
Material in this article is based upon Capt. J. D. James' ANC Handbook, The Design of Wood Aircraft Structures, with additional data and suggestions by M. P. Baker, assistant chief engineer, The Waco Aircraft Co., Troy, Ohio.

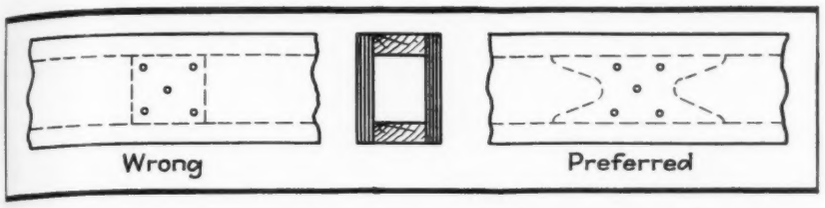
Lap, butt, and scarf joints all have their place in plywood construction. Since short lap joints place an eccentric load on the glue line, they are not recommended in aircraft skin construction. If butt joints are used they require the use of splice plates of adequate gluing area. If a butt joint is made directly on either solid or laminated wood without a splice plate, cleavage may occur at low stresses. Splice plates should be scarfed on their edges to avoid abrupt changes in section, which result in stress concentrations, and if made over relatively large wood members, should extend beyond their edges, also to avoid stress concentration.

Butt joints and splice plates should not be used in splicing beam webs. Preferred joint is either a straight or diagonal scarf joint. Length of a scarf joint should be about 20 times the thickness of the web. When scarf joints are made over large wood members they should be separated by splice plates the same as for butt joints. Splice plates may be made continuous along top or bottom of beams and be cut with scallops to serve as gussets at rib locations.

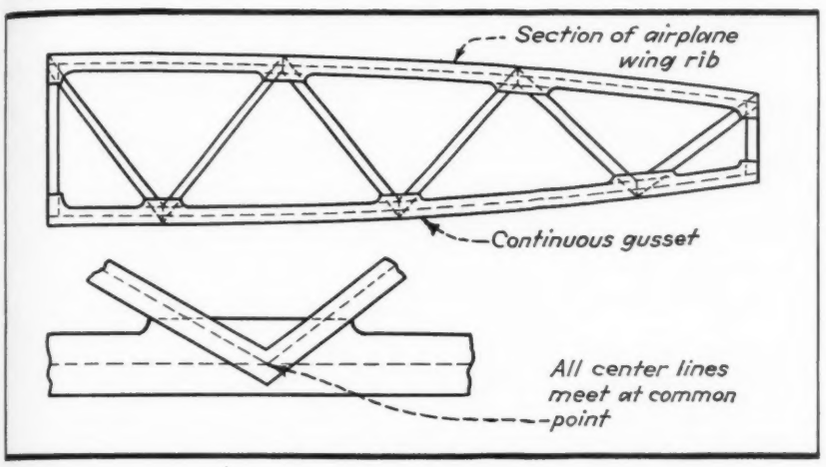
Thickness of plywood skin often should be tapered for structural efficiency so that strength varies with the load as closely as possible. A stepped taper is preferred, plies being added in pairs to maintain symmetry. Stress concentration is avoided by scarfing the edges or by scalloping.



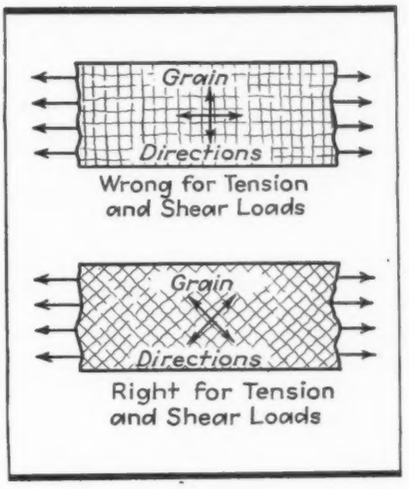




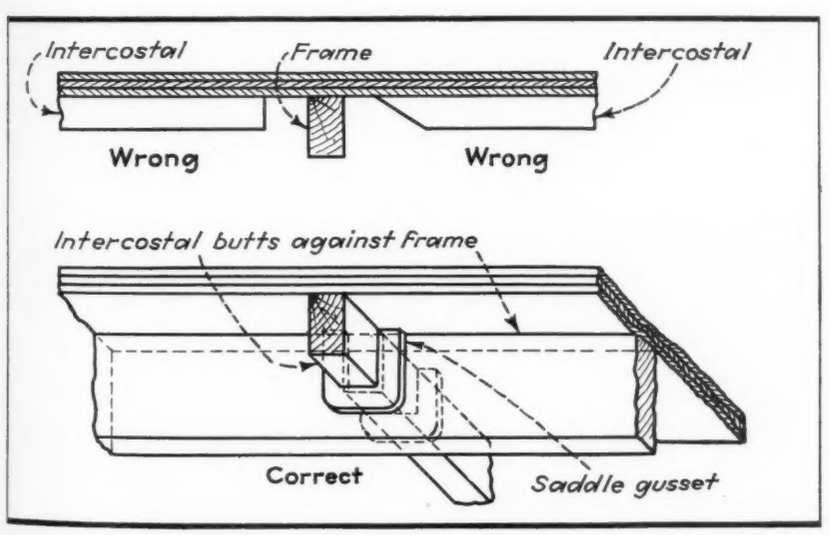
Blocking of box beams for attachment of fittings should be designed to avoid stress concentration at the corners of the block. By tapering out the four corners as shown, stress concentration is avoided. Possibility of checking is reduced by including cross-banded laminations in blocks.



Center lines of the struts should meet on the center lines of the rib caps to avoid eccentric loading in the most efficient truss construction. Actual fitting of the ends of struts, however, is not essential. Use of continuous gussets is one of several satisfactory types of construction. They have the advantage that they stiffen cap strips in the plane of the rib and are more easily handled than many small separate gussets. They also help in obtaining better rib-skin glue joints where nail gluing is used.

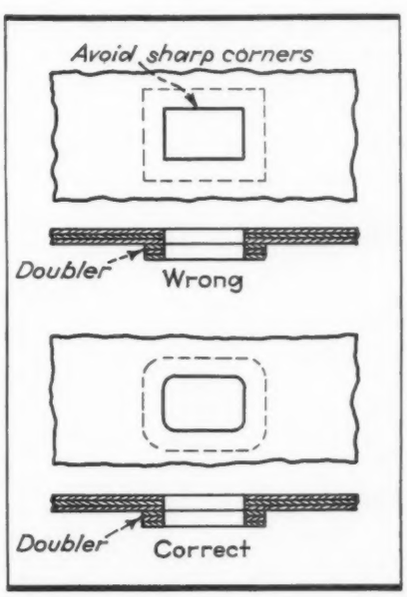


Grain directions should be diagonal when plywood skin is in tension. Square laid plywood tends to rupture before ultimate strength is reached. Some of the plies fail in tension as soon as the proportional limit, which is close to the ultimate tensile strength, is reached. None of the fibres of diagonal plywood are in pure tension and failures are the result of shear loading. Yield point beyond proportional limit in shear allows internal adjustment and deflection with the structure. Stiffness of diagonally laid plywood is approximately five times that of square-laid plywood. When used in shear webs of beams the face grain should be at right angles to the direction of possible shear buckles for greatest resistance to buckling.

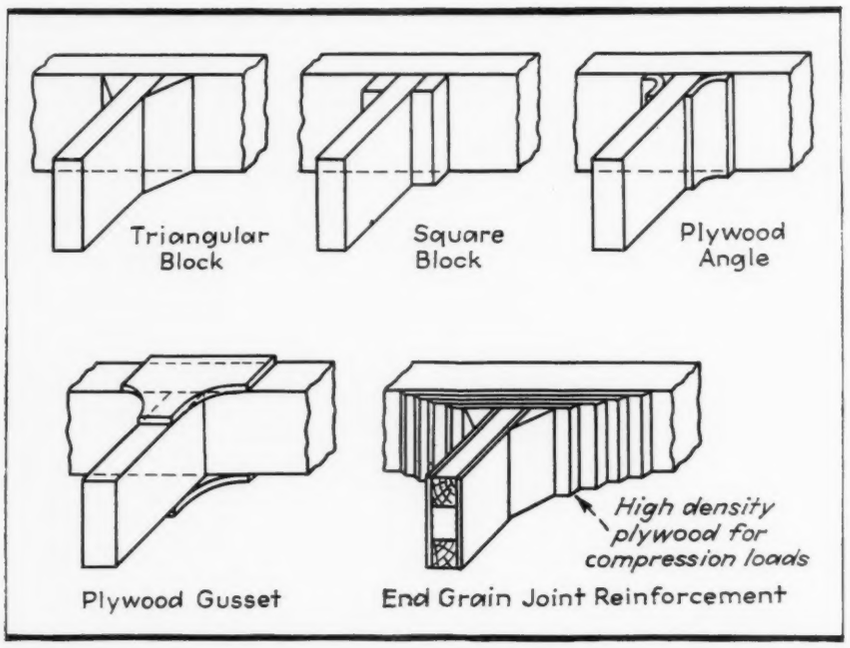


Intercostals should be butted against the rib or frame and fastened with saddle gussets or other means for safest construction. When they are terminated some distance from the rib or frame the result is usually cleavage along the glue line starting at the free end of the intercostal.

When ribs or frames are notched for stringers, the construction should be similar to the design described above except that a reinforcing block scarfed on both ends, must bridge the notch and be glued in place. The saddle gussets are then glued to both frame or rib, and reinforcing block.

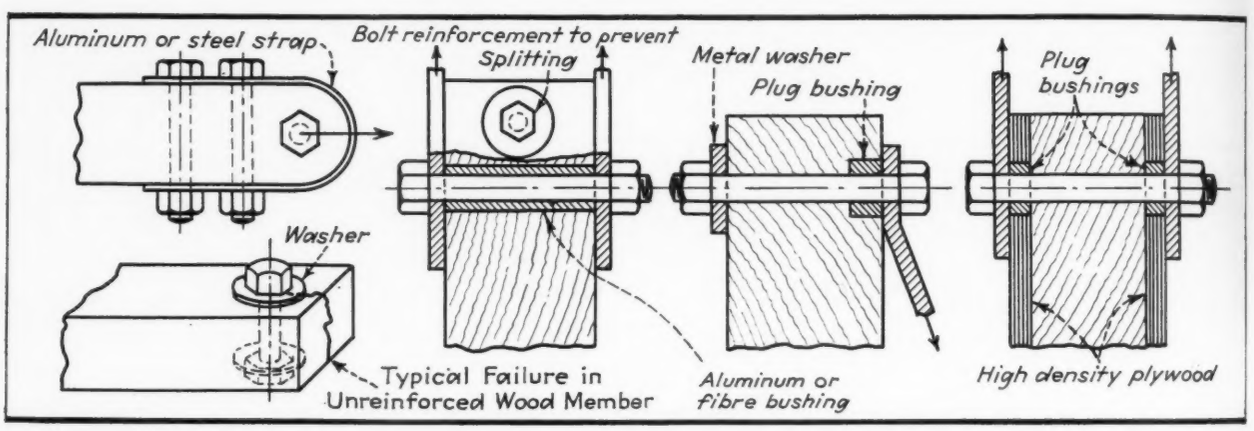


All openings through plywood skin should be rounded to avoid stress concentration at corners and should be reinforced by a doubler glued to the skin around the opening to overcome loss of strength produced by opening.

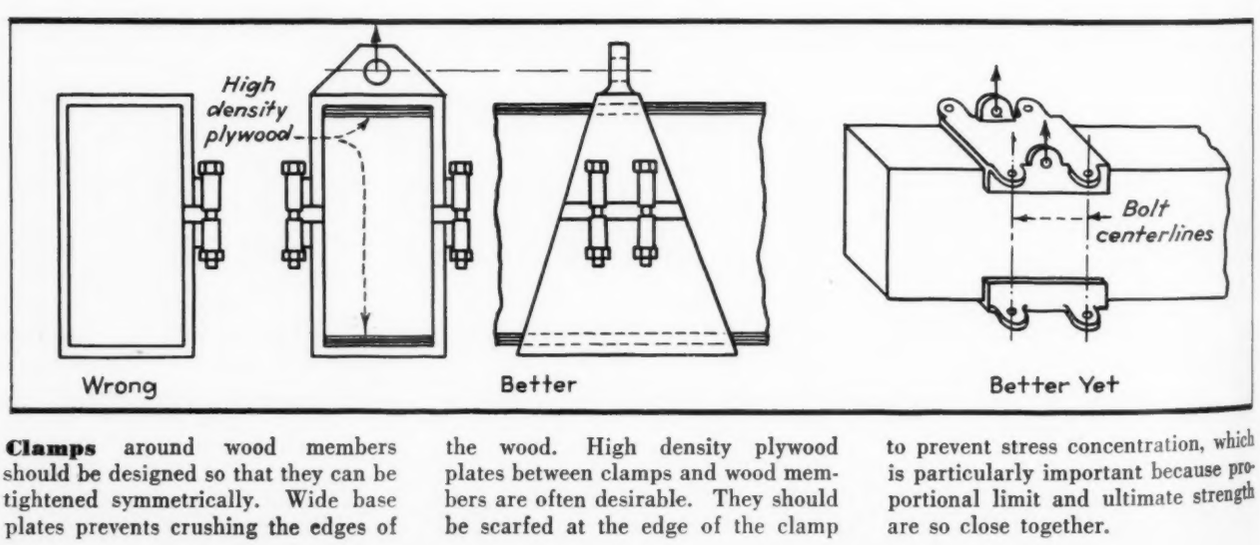


End grain glue joints may be strengthened satisfactorily by several types of reinforcement depending upon their size and the loads to be carried. If gussets are used they should have considerable overlap. High density plywood angles now find preference because long lengths are readily sawed to desired size. They are lighter and stronger than either triangular or square blocks. Grain directions in blocks must be selected carefully. Gussets can be combined with other types of reinforcement.

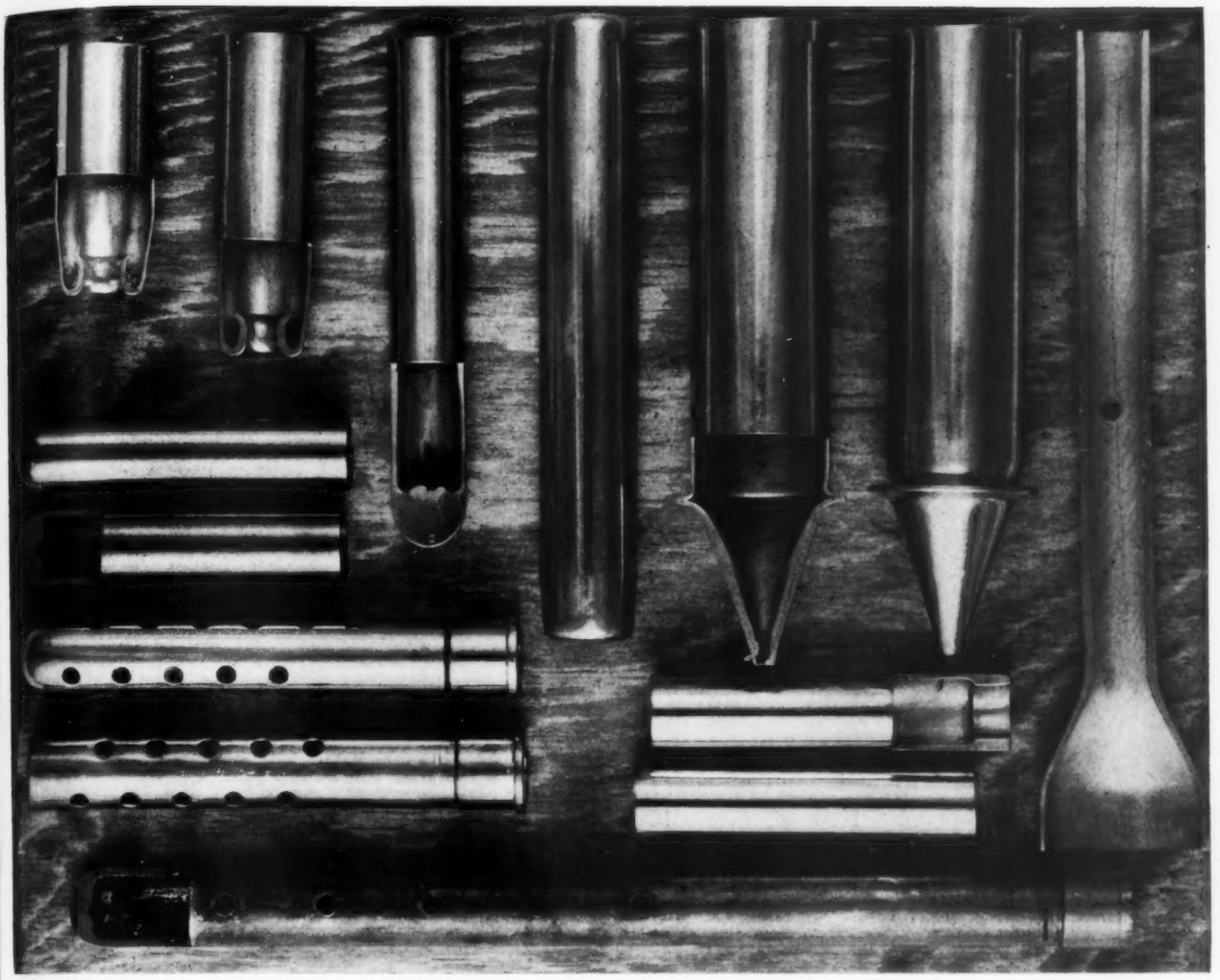
Compression loads on ribs or struts can be prevented from crushing a softer wood frame by plates of high density, such as compressed impregnated plywood. Metal angles can be substituted for the triangular blocks if the attachment must be stronger, but since bolts reduce the strength of the rib, this must be compensated in some manner.



Bushings around through-bolts increase bearing area. When the bushing goes all the way through it also enables tightening the bolt without crushing the wood. On long bolts weight may be saved by using a short bushing at the point or points of loading. Bushings may also be confined advantageously to high density face plates, when present. If metal washers are used, they should be of ample size to prevent cutting into the wood. When there are two or more bolts in a group it is preferable to use a washer plate.



Clamps around wood members should be designed so that they can be tightened symmetrically. Wide base plates prevents crushing the edges of the wood. High density plywood plates between clamps and wood members are often desirable. They should be scarfed at the edge of the clamp to prevent stress concentration, which is particularly important because proportional limit and ultimate strength are so close together.



Appearance of sections through tubes that have been formed on their ends by the Hill spinning process is shown by typical parts that have been sawed through the spun section

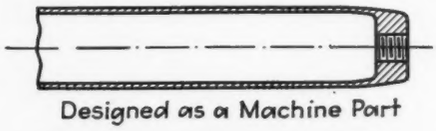
Tubular Parts Simplified By Tube Spinning Process

Shaping and closing the ends of tubing by means of a new spinning process enables designing parts to be made in one instead of several pieces, and thereby often eliminating deep drawing, forging, casting and machining operations. Simpler designs, faster production and lowered costs are the principal advantages.

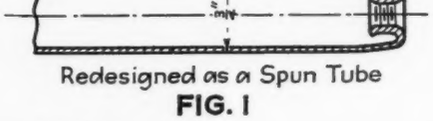
SHAPING and closing the ends of tubing by means of a new spinning process developed by Wolverine Tube Division of Calumet and Hecla Consolidated Copper Company offers engineers the opportunity to design tubular parts and containers with greater simplicity and fewer parts, thus increasing production speed and lowering costs.

The new spinning process requires no special machines. Ordinary drill presses, lathes, turret lathes, bar machines, or simple specially designed equipment can be employed. The only required elements are means of holding and feeding the tube, and means of holding and rotating the tool, which consists merely of a recessed die of the desired shape. The process works just as well if the tube is rotated and the die held stationary. Also, the die may be fed while the tube is either rotating or stationary. Skilled workers are not required.

Ten redesigns of parts now being made by the tube spinning process are illustrated in Figs. 1 to 10. These parts range from $\frac{7}{8}$ in. to 3 in. in diameter. Although no larger diameter tubing has yet been formed by

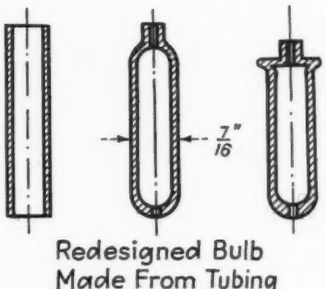


Designed as a Machine Part



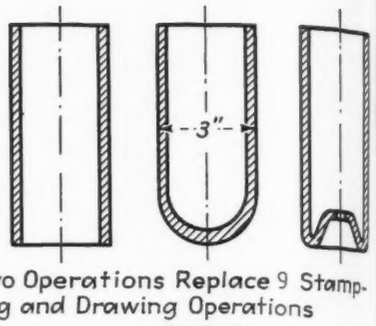
Redesigned as a Spun Tube

FIG. 1



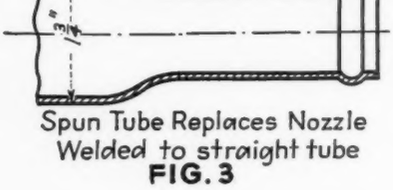
Redesigned Bulb Made From Tubing

FIG. 2



Two Operations Replace 9 Stamping and Drawing Operations

FIG. 6

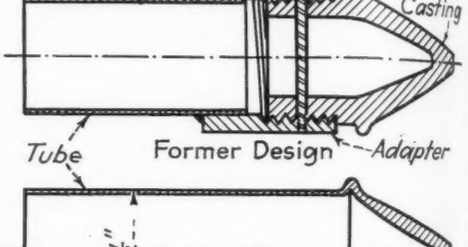


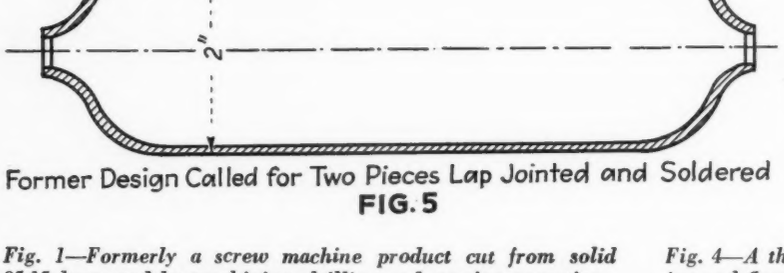
Spun Tube Replaces Nozzle Welded to straight tube

FIG. 3

Redesigned Spun Nozzle

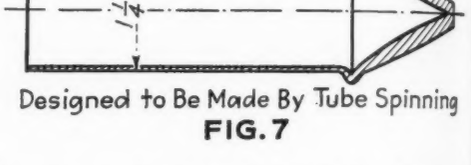
FIG. 4





Former Design Called for Two Pieces Lap Jointed and Soldered

FIG. 5



Designed to Be Made By Tube Spinning

FIG. 7

Fig. 1—Formerly a screw machine product cut from solid 85-15 brass rod by machining, drilling and tapping operations, this part is now produced by the Hill process

Fig. 2—Less than a third of the operations involved in stamping out this bulb are required when made by spinning a tube and upsetting

Fig. 3—A single spun tube replaces a piece of drawn tubing flared and then welded to a straight piece of tubing

Fig. 4—A three-part nozzle consisting of straight tube, stamping and flared tube welded together are now made in one piece

Fig. 5—Tubing with spun ends is an obvious improvement over two deep-drawn stampings soldered by older methods

Fig. 6—Deep-drawn stampings are commonly produced by several stamping operations starting with a disk blank. Tubing can now be closed on one end by spinning and forming to the desired shape

spinning, it is believed that no difficulty would be experienced. Tubing smaller than $\frac{1}{16}$ in. dia. has been spun successfully. The tubing may be seamed or seamless.

Tubing material may be brass, copper, monel metal, steel, aluminum or magnesium, according to Walter P. Hill, who developed the method. Parts illustrated by line drawings are, with the exceptions of Figs. 3 and 4, of copper and brasses. The exceptions are made of 3SO and 52S aluminum respectively. Figs. 1 and 6 are 85-15 and 70-30 brass respectively. Material for Fig. 10 was originally steel but was changed to copper for the new design. Figs. 5 and 6 were brass; are now copper. Figs. 2 and 8 are copper and Fig. 9 is two-and-one brass. Fig. 9 has also been made of 10-20 steel, the end being sealed by welding.

In Fig. 7 and 9 the tube ends are completely closed in the final form of the part. Closures in copper alloys and aluminum can be made in the spinning process without welding, brazing or soldering. Heat generated entirely by friction with the walls of the die raises the temperature of the metal during the operation, in some instances to 1,200 or 1,300 deg. F., in less than 1 sec. of time. The opening in the end of a tube can be reduced to microscopic size, according to Mr. Hill, and will seal against air pressure. In some instances a small opening is left which is sealed with solder. The beads in Figs. 2 and 7 are not produced by the spinning process but are formed in a punch press.

An assembly is performed on Fig. 10, which is a dryer tube filled with silica gel, before the ends are formed. The screen at one end is inserted before that end is formed, then the tube is filled with the drying agent and the second screen inserted before forming the other end of the tube. The tube of older design was filled through a hole in the side wall, which then had to be closed or sealed in some manner. This tube and the one in Fig. 5 are made also in larger sizes.

There is no limit to maximum wall thickness. Limits are only on thinness. It is possible to form a closure on a 2-in. tube with 0.016 in. walls. Such a tube can be crushed in the hand. One of the advantages of the process is the ability to thicken or upset the end. This may be carried so far as to make a solid rod out of tubing, which is of course impractical, but shows what can be done in the die. Several of the sketched parts show this thickening, Figs. 7 and 9 particularly, and the reproduced photograph of parts that are cut away.

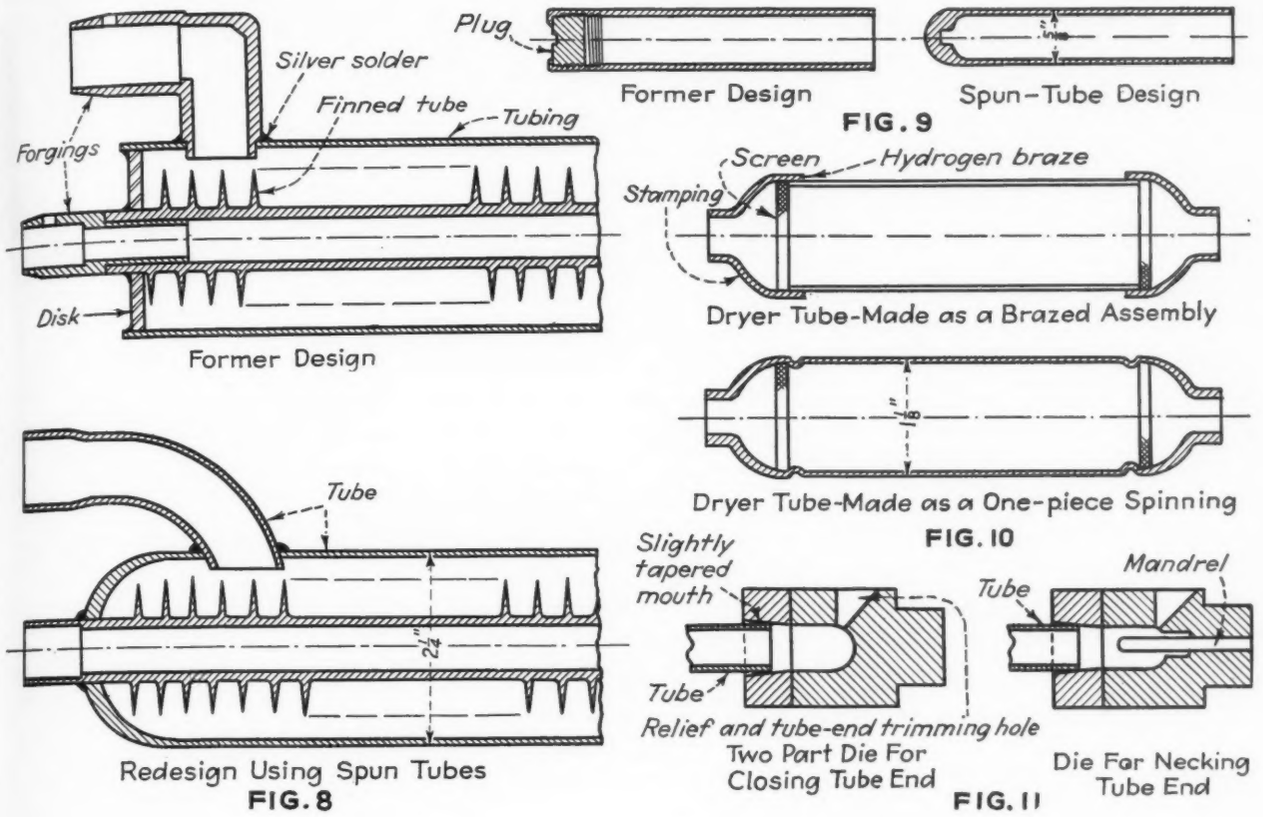


FIG. 9

FIG. 10

FIG. 8

FIG. 11

Fig. 7—Four parts including a tube, tapped adapter sleeve, threaded cast nose, the latter two parts drilled and tapped for a special screw, are eliminated by closing the end of a 70-30 brass tube

Fig. 8—Spinning process offers new possibilities in heat exchanger design using tubing only. In this instance two forgings, a disk, machining operations and two joints are eliminated thus reducing both production time and cost

Fig. 9—Formerly closed by a screw machined plug screwed into the tapped end of the tube, which was then peened over, this tube is now closed by spinning

Fig. 10—Spinning both ends of a dryer tube to narrow necks saved use of stamped ends hydrogen brazed to straight piece of tubing. Screen is placed before the spinning operation

Fig. 11—Cross-section of typical dies employed in Hill process. Tapered mouth produces a red heat in a split second

Dimensional tolerances on the spun ends of ½-in. O.D. tube, for example, can be held to plus or minus 0.002 in. This compares favorably with standard tube mill practice. In some instances, even closer tolerances can be held. This aided in the production of such products as telescoping aerials for the Signal Corps. Tube ends can be controlled for telescoping fits required in copper or silver brazing. The I.D. and O.D. tolerance can be controlled at the same time by using a mandrel.

Metallurgically, the spun end portions of tubes are refined in grain structure and strain lines produced in tube drawing operations are relieved. This refinement is the result of the high temperatures caused by frictional contact with the die, the heat annealing or recrystallizing the grain structure. Closures of tubes may have a grain size of 0.010 mm., and their increased ductility permits forming operations such as shown in Fig. 6, after spinning. Metal on the end of welded steel tubing that has been fully closed, has been so refined that the weld metal is indistinguishable from the original strip material, it is said. A full-hard tube has been formed, with the end soft for forming and the side walls unaffected.

While the process has been referred to as a spinning process, no fully descriptive name has been given to it. It has been defined as a process for hot forming by spinning without application of external heat. It depends upon controlled plastic deformation at a temperature developed by friction between the tube and a simple tool, one of which is rotating and the other stationary.

The process is extremely fast. Closures on brass primer tubes can be made at the rate of 600 to 2,500 per hr. depending on type of equipment. In no job attempted so far has the time exceeded 2 sec. per piece. Rate of production is governed by the speed with which the operator can chuck manually short cut lengths of tubing. Higher outputs would be possible with magazine feeds.

A relief hole drilled at 45 deg. through the die and into the arch at the bottom of the die cavity, as shown in Fig. 11, allows the metal to expand slightly as it reaches the hole and then be ironed again as it rubs against the solid metal in the arch. It also removes excess metal or bumps, thus leaving the spun end of the tube smooth.

Tool cost is almost negligible—a few dollars for a tool made of high-speed tool steel. Low-cost steels are usually as satisfactory as expensive hot-forming die steels for copper alloys and aluminum.

Commercial Tolerances for Springs

HAROLD CARLSON
Chief Engineer, Lee Spring Company

Although many spring manufacturers have agreed to certain commercial tolerances, some do not hold to them. Others have printed different standards in their company publications and some manufacturers of equipment using springs in their products have issued entirely different standards for the use of their engineers, designers and draftsmen. This article is an endeavor to end this confusion by presenting easily readable commercial tolerances in tabular form, based upon inherent variations caused by automatic spring coiling machines and manufacturing methods. Most of the tolerances are similar to those originally agreed upon, but have been enlarged to cover more conditions. More specific explanations and interpretations than were shown in the original tolerances are included, and nearly all tolerances have been reduced to three decimal places for convenience of inspection purposes.

ONE of the most controversial problems of the spring industry concerns commercial tolerances. This is because most designers are familiar with allowances and tolerances for turned shafts and other fitted members and attempt to apply those same tolerances to springs. Spring tolerances must be much larger than machined surface, casting or forging tolerances because of the unavoidable variations in wire size. Slight variations in wire diameters or in hardness of the wire cause a difference in the amount of "spring back" which occurs when wire is coiled. Wear on dies and tools used in automatic spring coilers should be considered as well. Some leeway on wire size, dimensions, and number of coils should always be given in order that springs may be made to meet the more important load and deflection requirements.

The solution of the problem of tolerances is in many cases left to the judgment of the spring maker. A great many drawings and specifications omit all reference to tolerances. In such cases, it is assumed that commercial tolerances are applicable or that the spring maker is familiar with the customer's usual requirements. If doubt exists regarding variations permitted, it is necessary quite frequently to obtain such information through correspondence, which causes delay and should be avoided as much as possible. Delays of this type may be avoided by adding a note to the drawing or specification stating that commercial tolerances are acceptable, or by specifying the tolerances shown in the tables that follow.

Even the commercial tolerances agreed upon by spring manufacturing companies require certain significant interpretations and in some instances it is necessary to devote additional time to the computation of tolerances which would be applicable. Much of this time can be saved by placing the required data in simplified tabular form and referring to it when necessary. Commercial tolerances are especially significant if it is realized that any spring developed within the limits indicated in the tables may be produced at a reasonable commercial cost, and in a comparatively short manufacturing time.

The commercial tolerance on all loads is 10 percent, specified as follows:

On compression springs:
100 lb. ± 10 percent at 4 in. compressed length.

On extension springs:
100 lb. ± 10 percent at 6 in. extended length inside of hooks.

On torsion springs:
100 in. lb. ± 10 percent at 45 deg. deflection; or 50 lb. ± 10 percent at 2 in. radius, at 45 deg. deflection.

Two loads with two deflections also may be specified but should be avoided because the manufacturing and testing time increases considerably. Where a specific amount of initial tension is required in extension springs the amount should be specified in pounds or ounces and the commercial tolerance to be applied is ± 15 percent.

Reductions to these load tolerances add considerably to the cost of the springs and to the manufacturing time because individual testing and adjusting of each spring becomes necessary.

In the tables that follow it will be observed that the spring index, the ratio of the outside diameter of a spring divided by its wire diameter, is a primary controlling factor in determining most tolerances. This relationship is very important in spring design and manufacture, for with small ratios less wire is used and less "spring back" occurs so that smaller tolerances are applicable. The number of coils per running inch of length, or the total number of coils, in a spring also affects tolerances, for with a large number of coils it is necessary to use larger tolerances.

The diameter tolerances are based on the outside diameters of springs. If a drawing specifies the inside diameter as the more important of the two, the tolerance based on outside diameter applies and should be indicated on the dimension showing the inside diameter.

When the spring index, outside diameter, re o.d., of a spring divided by the wire diameter, d, exceeds 12, larger tolerances than those listed herein are ordinarily required, but standards for springs of this type vary with each manufacturer and it is suggested that for conditions not covered by these tables the advice of a reputable spring maker be obtained.

In a large majority of spring applications, extreme accuracy of length and diameters need not be closely held to precision tolerances. In such cases it is far better to eliminate tolerances completely and add "approximate" on such dimensions or state "commercial tolerances are applicable." This would result in a reduction of manufacturing time, lower the cost and help to speed delivery.

Table I — Commercial Tolerances on Outside Diameter for All Coil Springs

Outside Diameter, in.	Plus or Minus Tolerance on O.D.		
	Spring Index (O.D. ÷ d)		
	Up to 7 (Small)	7 to 11 (Average)	11 to 13 (Large)
Up to 1/8, inc.	0.002	0.003	0.004
Over 1/8 to 3/16, inc.	0.003	0.004	0.006
Over 3/16 to 1/4, inc.	0.004	0.006	0.008
Over 1/4 to 3/8, inc.	0.006	0.008	0.010
Over 3/8 to 1/2, inc.	0.008	0.010	0.012
Over 1/2 to 3/4, inc.	0.010	0.012	0.015
Over 3/4 to 1, inc.	0.012	0.015	0.022
Over 1 to 1 1/2, inc.	0.015	0.022	0.031
Over 1 1/2 to 2 in.	0.022	0.031	0.047
Over 2 to 3, inc.	0.047	0.062	0.094
Over 3 to 4, inc.	0.062	0.094	0.125
Over 4 to 5, inc.	0.094	0.125	0.156

Table II—Commercial Variation on Squareness of Grinding on End Coils (for compression springs only)

Number of Coils per Inch of Length (Length ÷ Number of Coils)	Maximum Variation in Degrees From Squareness to Axis		
	Spring Index (O.D. ÷ d)		
	Up to 7 (Small)	7 to 11 (Average)	11 to 12 (Large)
Up to 7, inc.	3	4	5
Over 7 to 12, inc.	4	5	6
Over 12 to 17, inc.	5	6	7
Over 17	6	7	8

1. These variations in degrees may be reduced 50 percent by individually grinding, measuring, testing and sorting the springs, but this increases production time and cost.
2. Grinding end coils of springs made from wire under 0.025 in. dia. is usually unnecessary and frequently is expensive.

Table III—Commercial Tolerances on Length for Compression Springs With Ground Ends and for Accurately Made Extension Springs

Length of Spring, in.	Total Number of Coils	Plus or Minus Tolerance on Length, in.		
		Spring Index (O.D. ÷ d)		
		Up to 7 (small)	7 to 11 (average)	11 to 12 (large)
Up to 3/4, inc.	Up to 4, inc.	0.007	*0.011*	0.015
	Over 4 to 7, inc.	0.011	0.015	0.018
	Over 7 to 11, inc.	0.015	0.018	0.022
	Over 11	0.018	0.022	0.026
Over 3/4 to 1 1/2, inc.	Up to 5, inc.	0.010	*0.015*	0.020
	Over 5 to 10, inc.	0.015	0.020	0.025
	Over 10 to 15, inc.	0.020	0.025	0.030
	Over 15	0.025	0.030	0.035
Over 1 1/2 to 2 1/2, inc.	Up to 10, inc.	0.020	*0.030*	0.040
	Over 10 to 20, inc.	0.030	0.040	0.050
	Over 20 to 30, inc.	0.040	0.050	0.060
	Over 30	0.050	0.060	0.070
Over 2 1/2 to 3 1/2, inc.	Up to 15, inc.	0.030	*0.045*	0.060
	Over 15 to 30, inc.	0.045	0.060	0.075
	Over 30 to 45, inc.	0.060	0.075	0.090
	Over 45	0.075	0.090	0.105
Over 3 1/2 to 4 1/2, inc.	Up to 20, inc.	0.040	*0.060*	0.080
	Over 20 to 40, inc.	0.060	0.080	0.100
	Over 40 to 60, inc.	0.080	0.100	0.120
	Over 60	0.100	0.120	0.140
Over 4 1/2 to 6, inc.	Up to 25, inc.	0.050	*0.075*	0.100
	Over 25 to 50, inc.	0.075	0.100	0.125
	Over 50 to 75, inc.	0.100	0.125	0.150
	Over 75	0.125	0.150	0.175
Over 6 to 8, inc.	Up to 35, inc.	0.070	*0.105*	0.140
	Over 35 to 70, inc.	0.105	0.140	0.175
	Over 70 to 100, inc.	0.140	0.175	0.210
	Over 100	0.175	0.210	0.245
Over 8 to 10, inc.	Up to 45, inc.	0.090	*0.135*	0.180
	Over 45 to 90, inc.	0.135	0.180	0.225
	Over 90 to 135, inc.	0.180	0.225	0.270
	Over 135	0.225	0.270	0.315
Over 10 to 14, inc.	Up to 60, inc.	0.120	*0.180*	0.240
	Over 60 to 120, inc.	0.180	0.240	0.300
	Over 120 to 180, inc.	0.240	0.300	0.360
	Over 180	0.300	0.360	0.420
Over 14 to 18, inc.	Up to 80, inc.	0.160	*0.240*	0.320
	Over 80 to 160, inc.	0.240	0.320	0.400
	Over 160 to 240, inc.	0.320	0.400	0.480
	Over 240	0.400	0.480	0.560
Over 18 to 22, inc.	Up to 100, inc.	0.200	*0.300*	0.400
	Over 100 to 200, inc.	0.300	0.400	0.500
	Over 200 to 300, inc.	0.400	0.500	0.600
	Over 300	0.500	0.600	0.700
Over 22 to 28, inc.	Up to 125, inc.	0.250	*0.375*	0.500
	Over 125 to 250, inc.	0.375	0.500	0.625
	Over 250 to 375, inc.	0.500	0.625	0.750
	Over 375	0.625	0.750	0.875

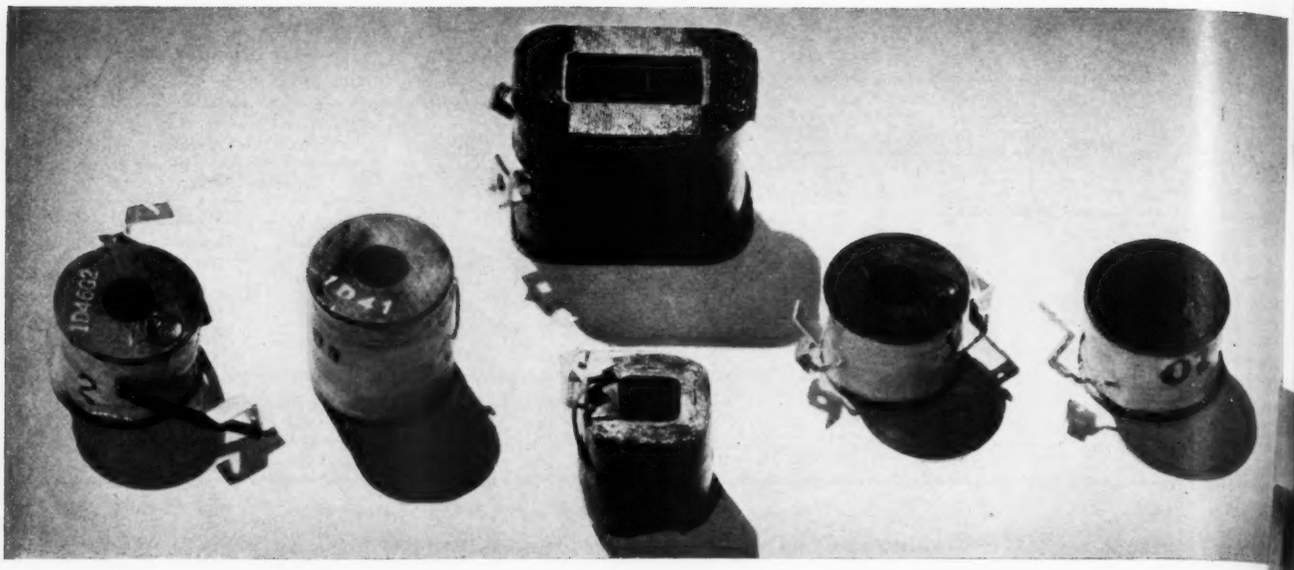
1. These tolerances may be reduced 50 percent by individually grinding, measuring, testing and sorting the springs, but this procedure increases production time and cost.
2. These tolerances should be doubled for compression springs that do not have ground ends and for the usual run of commercial extension springs.
3. The valves in italics are standard when the wire diameter or number of coils is not predetermined, or where there is doubt.

Table IV—Commercial Tolerances on Wire Diameters

Wire Diameter, in.	Plus or Minus Tolerance on Wire Diameter	
	Music Wire	All Other
Up to 0.020, inc.	0.0002	0.00025
Over 0.020 to 0.040, inc.	0.0003	0.0005
Over 0.040 to 0.060, inc.	0.0005	0.00075
Over 0.060 to 0.080, inc.	0.0008	0.001
Over 0.080 to 0.177, inc.	0.001	0.0015
Over 0.177 to 0.375, inc.	.....	0.002
Over 0.375	.....	0.003

Table V—Commercial Tolerances on Number of Coils

Total Number of Coils	Tolerance, Plus or Minus
Up to 4, inc.	1/4 coil
Over 4 to 8, inc.	1/2 coil
Over 8 to 15, inc.	3/4 coil
Over 15 to 25, inc.	1 coil
Over 25	1 1/2 coils



Corrosion Causes and Remedies In Fine Wire Magnet Coils

B. W. ERIKSON
Industrial Control Engineering Department
General Electric Company

An analysis of the mechanics of failures caused by moisture in fine wire magnet coils, with a description of when and where corrosion occurs. Included also is a discussion of some possible and prospective remedies for eliminating corrosion troubles. Characteristics of typical insulation materials are also enumerated.

GENERAL experience over a number of years has proved that relay and contactor open-circuit coil failures are caused by the effects of moisture at least 75 percent of the time. This is particularly true of small devices and those subject to only periodic service as contrasted with continuous operation.

Through a recognition of the destructive effects of moisture on an insulation system, necessary precautions can be taken in the early design stages to build in moisture and corrosion resistance where it will do the most good. By continual mention of these facts, the author hopes that no coil design will ever again be made which does not have adequate provision against moisture corrosion, at least where fine wires are involved.

Aggravating the problem is the fact that today designers are striving for small relay designs to operate at voltages up to 600 volts and often in ambient temperatures of 100 deg. C. Voltage rating is often a dominating factor, because the higher the voltage the smaller is the proper wire diameter required on the coil.

Coils for voltages above 24 volts are often made of extremely fine wires, frequently 3, 2 or even 1 mil in bare diameter. It is for this reason that corrosive factors assume such importance. Obviously, the small diameter copper wire will corrode off much faster than the larger diameter wire used in coils for larger designs.

Open circuit coil failures caused by moisture-initiated copper-electrolysis account for the majority of service interruptions. Such copper corrosion is usually the result of direct electrolysis or current leakage through the insulation. This leakage is made possible and accelerated by water soluble chemical salts in the insulation materials or by free acids which may generate in the insulation through the reactions of the electro-chemical changes taking place in service. The free acids, where these occur, are usually derived from organic decomposition of vegetable or animal gums used as stickers on various papers and tapes. Corrosion as a result of either of these causes shows up as a greenish salt deposit (copper soaps) on the wire itself and on the surrounding insulation. Examples of the formation of these deposits are illustrated in Figs. 1, 2 and 3. In other words, where a greenish discoloration of wire or insulation is evident, moisture is the primary cause.

The slight corrosiveness of so called corrosion-proof soldering fluxes, and the negligible amounts of chemical impurities common in insulation materials such as cellulose base papers or tapes, is all that is needed to produce open circuits in a short period of time, often measured in days. This statement is true for coils on either a.c. or d.c. circuits with the distinction that:

1. Corrosion may take place on both a.c. and d.c. in the presence of moisture

when the coils are not energized if the insulation contains free acids.

2. Corrosion seldom occurs on a.c. or d.c. coils if these are continuously energized. The heating incident to operation keeps the coil dry.

3. Corrosion is particularly violent on d.c. when the coil is subject to moisture and connected to a positive d.c. potential with no current flowing through the coil. In this case, it is d.c. leakage to ground and subsequent electrolytic action made possible by free ions obtained from the insulating materials used, which in time completely decomposes the positive coil wires. If connected to negative potential, no corrosion will take place.

4. Corrosion and breakage of the coil wires also occur on d.c. coils intermittently energized, which in the "off" period moisture is absorbed. This is followed by terminal-to-terminal leakage during the period before the heat of the coil drives off the moisture content. This process if repeated a few times, dependent on humidity of surroundings and time of exposure, soon results in an open circuit.

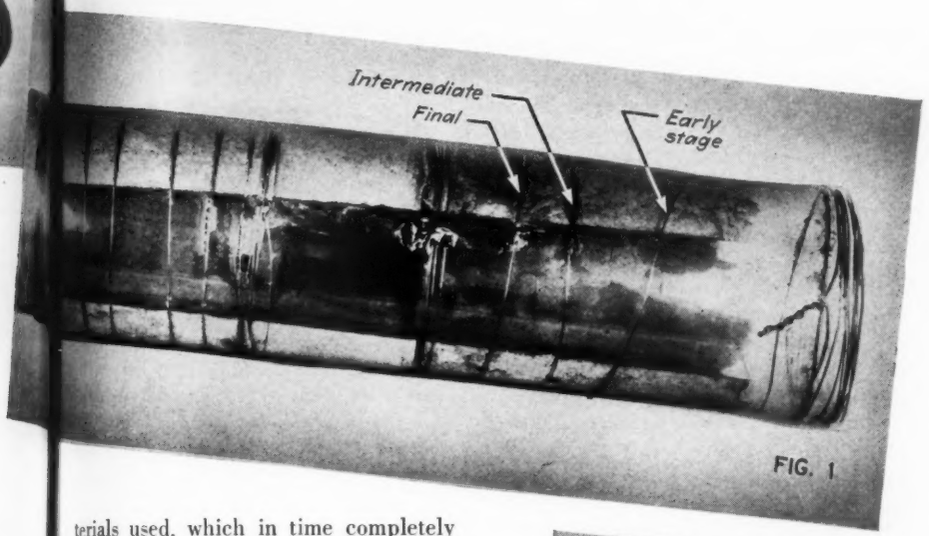
It has repeatedly been demonstrated that length of time of exposure to moisture with the coil de-energized is far more deadly to its life than are much higher moisture exposures for short periods or with the coil energized.

Also, failures occur at a rate which increases rapidly with increases in percentage moisture, other conditions remaining constant. Many coils that on tests at 90 percent humidity last almost indefinitely, will fail within a few days on a change to 95 percent humidity. At 100 percent, the rate of failure again increases very sharply.

Some observations of a test will bear out these statements. A group of 20 coils designed for 95 percent humidity, had been on test for 14 days with but one failure, at which time the humidity was increased to 100 percent. In the following three days, all coils failed. These coils were tested on a schedule of 2 hr. "on", 10 hr. "off". Again, coils which will normally stand a 2 hr. "on", 10 hr. "off" daily cycle at 100 percent humidity for 10 to 30 days often fail in 4 or 5 days at 100 percent humidity with potential to ground only and no current flowing through coil. This latter condition is, therefore, by far the most serious if encountered in actual practice, and should be avoided.

In the design of coils suitable for service under severe moisture conditions as outlined, often complicated by the addition of maximum total operating temperatures as high as 150 deg. C., only a few materials will do. Subject to some modifications, the materials briefly are mica, asphalt, cellulose acetates and glass products not coated with corrosive lubricants. Figs. 4 and 5 illustrate a few types of spun glass and cellulose acetate spools. Most glass yarns and tapes, as well as cellulose acetate yarns, are corrosive because of the oil applied in the spinning, consequently they should be used with caution.

In addition, there are several synthetics that are strictly non-corrosive, notably the nylons. It is from these fields of future synthetic developments that considerable help may be expected in the next few years. Much research is being done along these and other lines by several nationally known chemical companies working in cooperation with electrical manufacturers. Progress is definitely in the making. Certainly, it



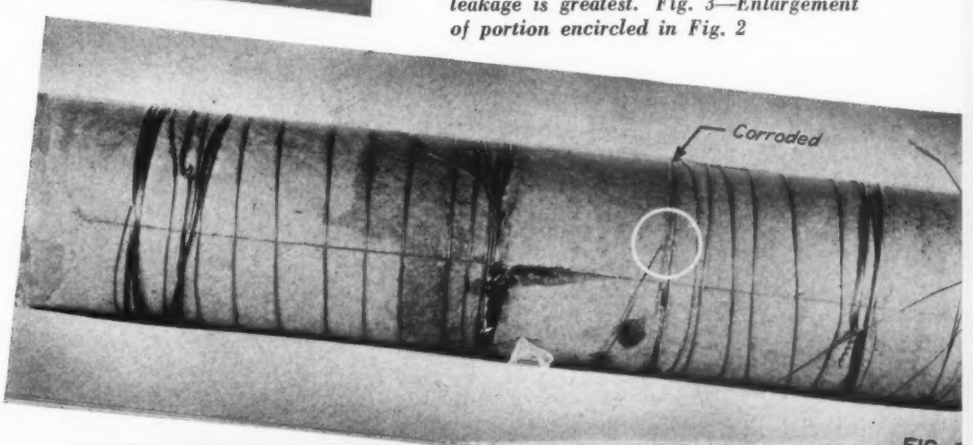


Fig. 1—Laboratory sample coil showing three stages of corrosion. Fig. 2—Microphoto of fine copper wire coil in different stages of corrosion. Worst corrosion is evident in wires at center of test coil where potential difference and current leakage is greatest. Fig. 3—Enlargement of portion encircled in Fig. 2

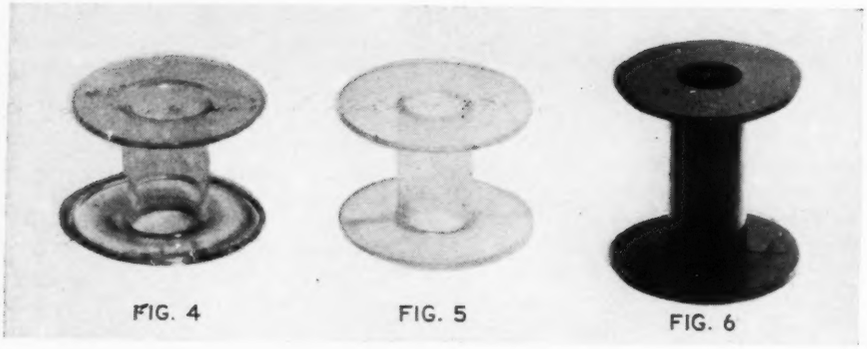


FIG. 4 FIG. 5 FIG. 6

Fig. 4—Spun glass spool. Fragile, requires large dimensional tolerances but strictly non-corrosive. Fig. 5—Cellulose acetate injection molded spool, limited to about 100 deg. C. applications. Corrosion free. Fig. 6—Phenolic compound molded spool

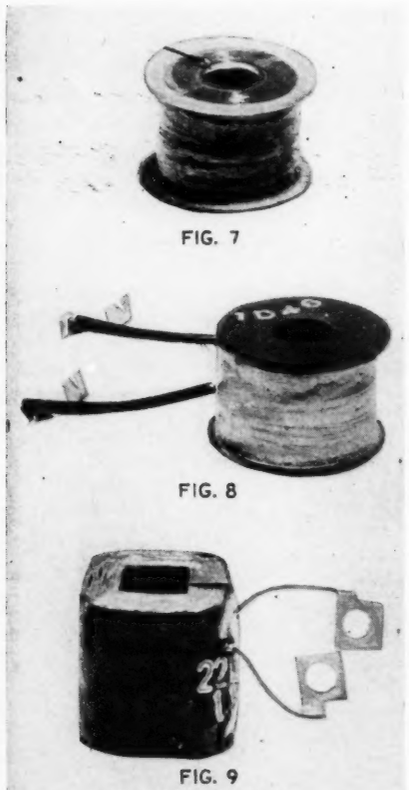


FIG. 7

FIG. 8

FIG. 9

Fig. 7—Completely acetate insulated coil wound on injection molded cellulose acetate spool body, non-corrosive. Fig. 8—Acetate insulated coil on pressure molded phenolic compound. Corrosion resistant, but not corrosion proof. Fig. 9—Conventional paper layer wound small relay coil made with common corrosive materials. Not good in humid applications

is known that the natural insulating materials available today cannot be used for corrosion-free, high-temperature coil structures at reasonable costs. Without satisfactorily solving the cost angle, there will be no real gains.

At present there is in use only one type of design which may be classed as corrosion-free, this is the so called "acetate" construction. These are coils fabricated chiefly from cellulose acetate and may consist of injection-molded acetate spools like those shown in Figs. 5 and 7, with a cover of sheet acetate. Another construction would consist of a phenolic molded compound spool completely insulated with cellulose acetate sheet and washers and covered with acetate cement, like that shown in Fig. 8. Still another way would be to use coils which are layer wound similar to the paper layer method, but which employ acetate sheet material throughout. Fig. 9 shows such a construction.

It should be noted that all common insulation materials such as papers, tapes, string, including glass string, twines, varnished cambric, molded materials (with the possible exception of so-called ammonia-free compounds), fibre, and practically all commercially trademarked insulations, unless of cellulose acetate or other synthetic compositions, are corrosive. Even very small pieces of any of these materials in an otherwise corrosion-free coil is enough to cause failure.

What is needed in addition to the acetates, mica, and asphalts (Fig. 10 shows asphalt treated coil) to simplify designs is a new material that is non-corrosive, non-thermoplastic up to 150 deg. C. or higher (acetate at this temperature is quite soft and gradually shrinks and hardens), non-shrinking and not subject to accelerated aging of any of its characteristics at 150 deg. C. It should further be available in sheet form, flexible, easily punched, cut and formed, and if possible, soluble to a non-corrosive, quick-setting solvent or sticker and suitable for molding.

Pending the arrival of such a "cure-all" material, coil designers should be continually on the watch for improvements and also constantly testing existing materials. Even with what is available a good job can be done provided moisture-consciousness is maintained from the beginning of the design and the coil engineer is allowed a free hand in the selection of suitable materials. The truth of this becomes evident when considering the relative perfection of design and lack of failures arrived at on large-production contactor coils like the one shown in Fig. 10, as well as solenoid and brake coils manufactured for industrial control purposes and used under severe operating conditions.

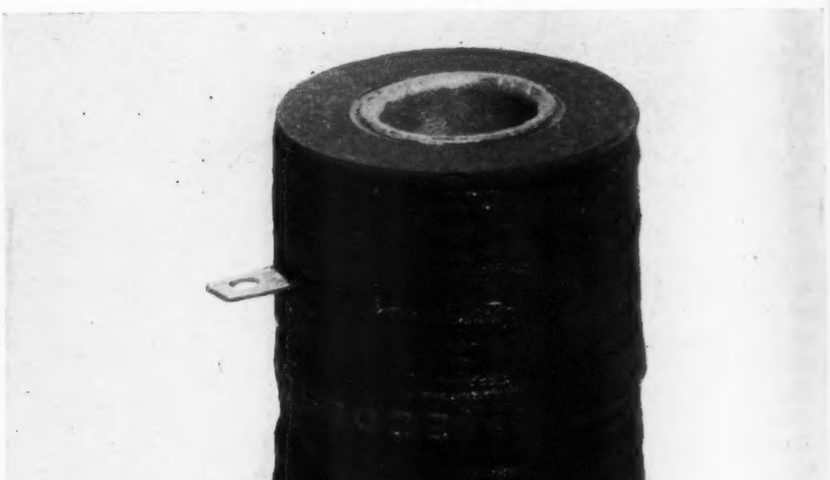
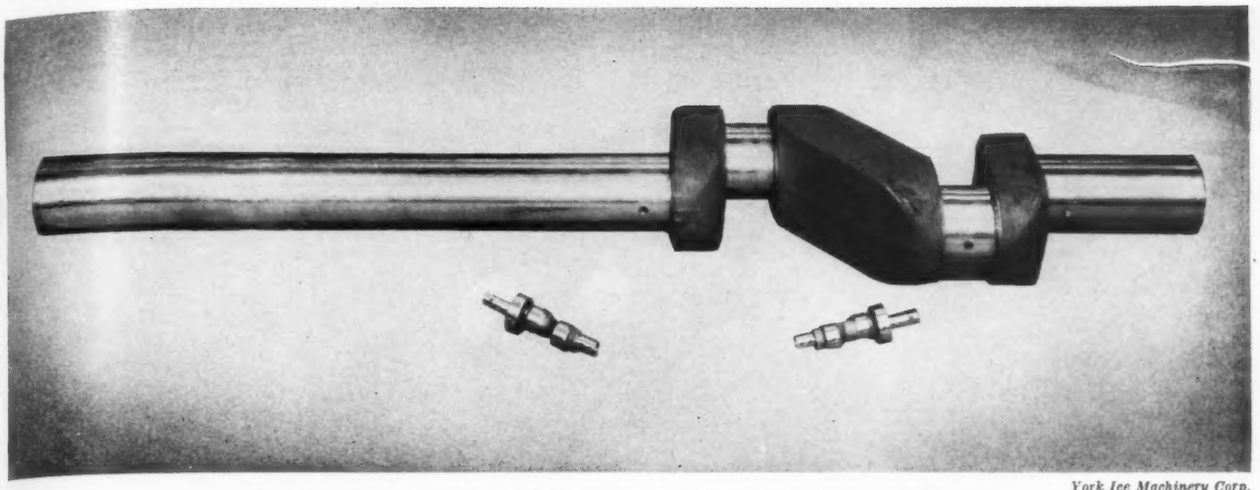


Fig. 10—Large conventional contactor coil made with a minimum of corrosive materials. Insulated with mica and impregnated with an asphaltic compound



York Ice Machinery Corp.

Crankshafts ranging from 3 to 1300 lb. have been changed to high-strength cast iron. Large shaft is 8 ft. 6 in. long. One of the small shafts is forged, the other cast

Iron Castings Replace Forgings For Highly Stressed Parts

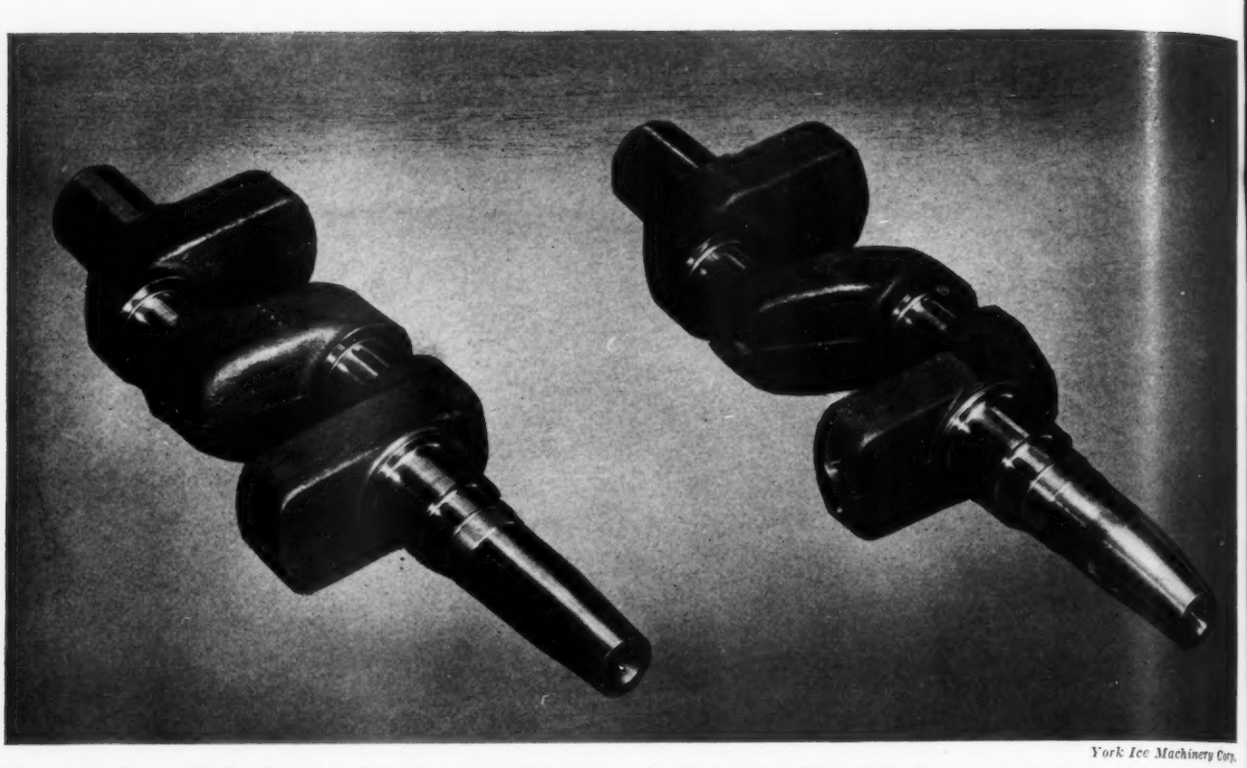
Use of high-strength cast iron to replace forged steel in machine and engine parts is meeting with success in an increasing number of applications. Although limitations of forging facilities has stimulated this trend, the indications are that most changes will be permanent. Some of these design changes, including crankshafts and connecting rods, are described and illustrated.

USE of any kind of cast iron in machine members that are highly stressed would not have been considered a few years ago under any circumstances. Improvements in the technique of producing castings so that they are sound and homogeneous have done much to change the quality and dependability of cast iron. The best grades now are much more highly regarded among design engineers. Perhaps only a small percent of the cast iron produced need be of this high quality but the significance of this small percent is great.

Evidence of the importance of high-quality, high-strength cast iron can be found in recent changes of materials stimulated by priorities and shortages of the materials customarily used in highly stressed parts. Such changes had, of course, been tried out experimentally at least, before the past year's urgency speeded up and multiplied them. Up to that time the human tendency to let well enough alone previously designed machines or parts that were operating satisfactorily more nearly balanced competitive designing for low cost production. New materials were tried out with great caution when there was much at stake.

The actual dependence that can be put in high-strength cast iron, such as Meehanite and Proferall, is well illustrated by their successful use in crankshafts and connecting rods. Cooper-Bessemer Corporation, for example, is using Meehanite interchangeably with forged steel for its 9½-in. dia. crankshaft in its two-cycle gas-engine-driven Type GMV compressor units. York Ice Machinery Corporation has changed over nearly its whole line of compressors to cast iron crankshafts and has had three years of experience to show the wisdom of this decision. While many materials changes were precipitated by the war, these are by no means to be considered as temporary substitutions. There has been enough experience now to show that the change from steel forgings to cast iron has enough advantages, both in economy and flexibility of design, that there will be no return to forgings even when they can be obtained readily. Neither firm has had a single failure of a cast iron crankshaft. There are a large number of York machines so equipped in service.

The shaft material used by Cooper-Bessemer is Meehanite M50(A) with slight compositional changes. York uses both Proferall and Meehanite. The former, as used in York crankshafts, has a tensile strength of 55,000 lb. per sq. in. and the Brinell hardness is specified from 250 to 325. In a laboratory fatigue test using selected shafts as test specimens, it would be found that the steel shaft has a longer life than the cast iron shaft. However, under actual production conditions, there is reason to believe that the higher theoretical fatigue strength of the steel may not be fully obtainable. No matter how carefully the machining job is done, there may be a scratch or tool mark on the finished surface that is slight enough or located so as to be unimportant dimensionally on the finished shaft but has a notch effect that causes stress concentration. Cast iron is less notch sensitive than steel so that any deviation from perfection in machining will not affect the cast iron shaft as it will the steel shaft. In this way the maximum fatigue life of the cast iron may well



York Ice Machinery Corp.

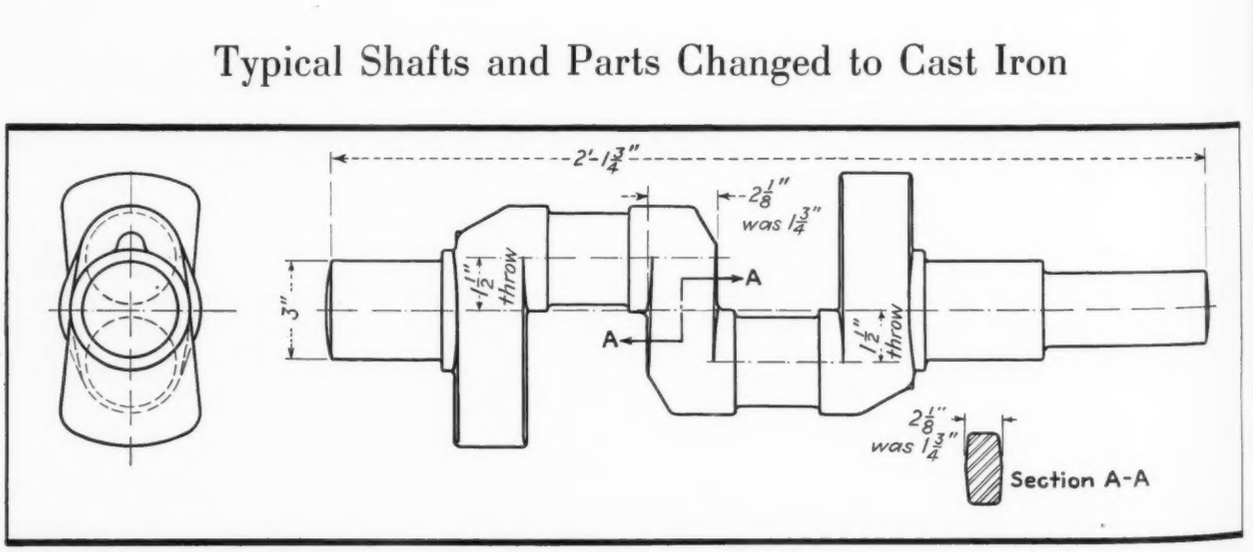
These interchangeable Meehanite and die forged crankshafts may be distinguished by slight thickening of the web section of the cast shaft. Surfaces of the unmachined portions of the shafts are about equally good

be counted on, while it would be wise to use a factor of safety with respect to that of the steel shaft.

A further important consideration in the selection of cast iron in crankshafts or other stressed members is that cast iron dampens vibration much more than steel. Since fatigue results from vibration and stress reversals, the importance of damping properties of cast iron in reducing fatigue is evident. The less expense and difficulty in altering a pattern than a forging die when design changes become desirable are important considerations also.

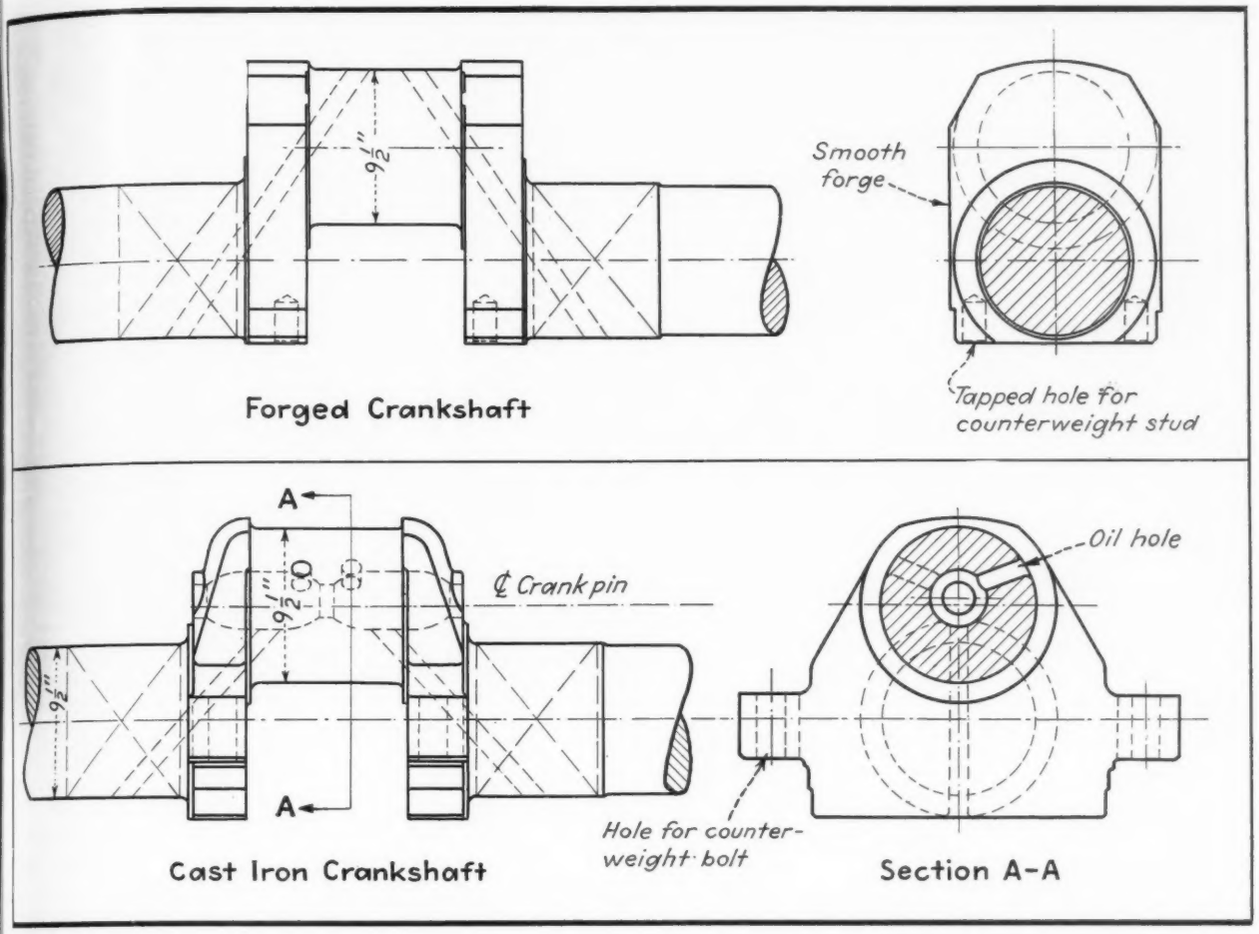
Design changes in the group of crankshafts and other parts that are described in this article are in general a thickening of section, and in all instances the cast iron parts are interchangeable with the forged steel parts that they replaced. However, this may not always be possible in making such changes. The accompanying illustrations show where the changes were made in design of parts.

Typical Shafts and Parts Changed to Cast Iron



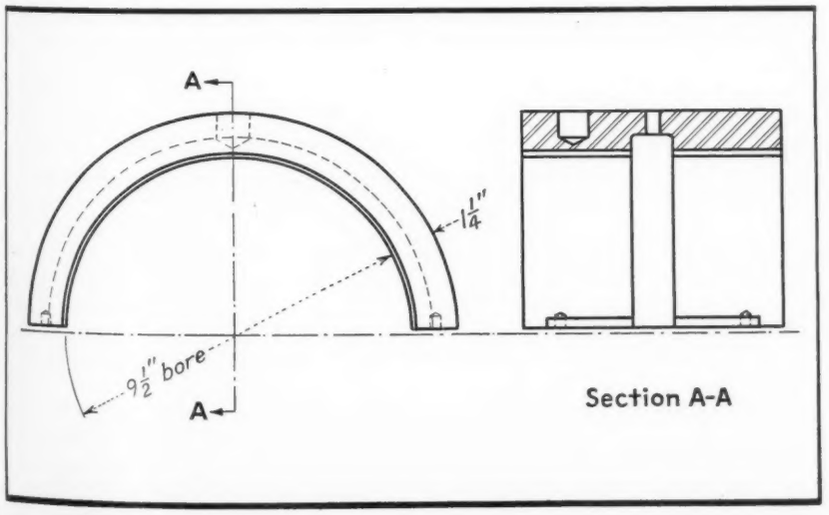
Pattern drawing of another compressor shaft used in refrigeration compressor service shows the design changes made to adapt a cast iron crankshaft to take the load formerly carried by a die forged crankshaft. The two crankshafts are interchangeable and thickening of section A-A is the only significant dimension change.

The material is specified to have "a minimum tensile strength of 55,000 lb. per sq. in. and a Brinell hardness of 255 to 321. Casting to be clean and absolutely free from scale. Stress relieved." The forged steel was a 0.40 carbon steel with heat-treatment varied according to the size of the piece. Tensile strength was 85,000 minimum.



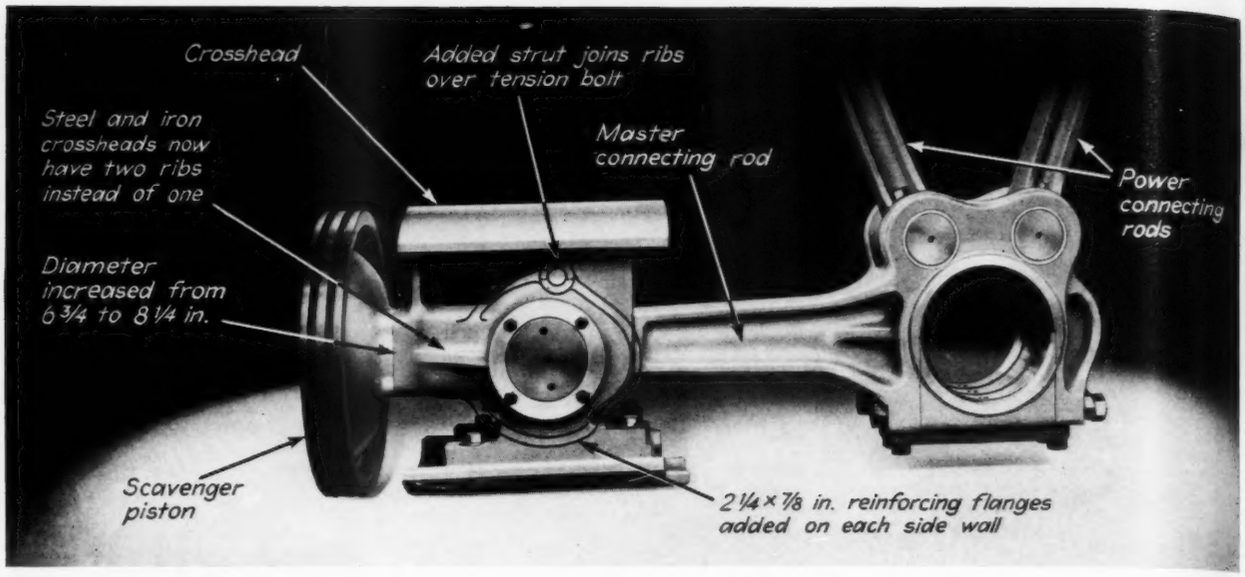
The 9½-in. dia., 12-ft. crankshaft on the two-cycle gas-engine-driven Type GMV compressor units is a gradual development worked out by the Cooper-Bessemer foundry and engineering department. At present it is cast in two parts, flanged and bolted together. This made it unnecessary to install larger foundry equipment to accommodate shafts over 9 or 10 ft. long. A two-part shaft is practical on this particular engine because, being designed primarily for compressor service, it has exceptionally wide cylinder centers.

One of the main advantages of the cast iron shafts is that their webs are not machined, while on large forged shafts it is usually necessary to machine all over. Use of the cast shafts, therefore, saves much milling time. The same tolerances are specified on the finished surfaces. No noticeable difference has been noted in wear or lubrication of the connecting rod bearing. Before putting these shafts in gas engine service a long test run was made in diesel engine operation, which put on the shaft a load almost double that which it would normally carry. The shaft took this punishment without damage. Cost of the Meehanite crankshafts is 20 to 30 percent less than the forged steel shafts, which makes the change an important saving and relief now to forging facilities.



Main bearing shell was changed from forged or rolled steel to cast Meehanite for an entirely different reason. There were no changes in its proportions because the shell is always under compression and is well supported. Inability to obtain a satisfactory bond between babbitt and cast iron has often prevented the use of cast iron where such bonds are required. Cooper-Bessemer is getting a satisfactory bond between high lead babbitts, as well as tin babbitts, and cast iron by using the Kolene process, without machined anchoring grooves. EDITOR'S NOTE—For more information on the Kolene process see "What's Coming" on the contents page.

(*continued on next page*)

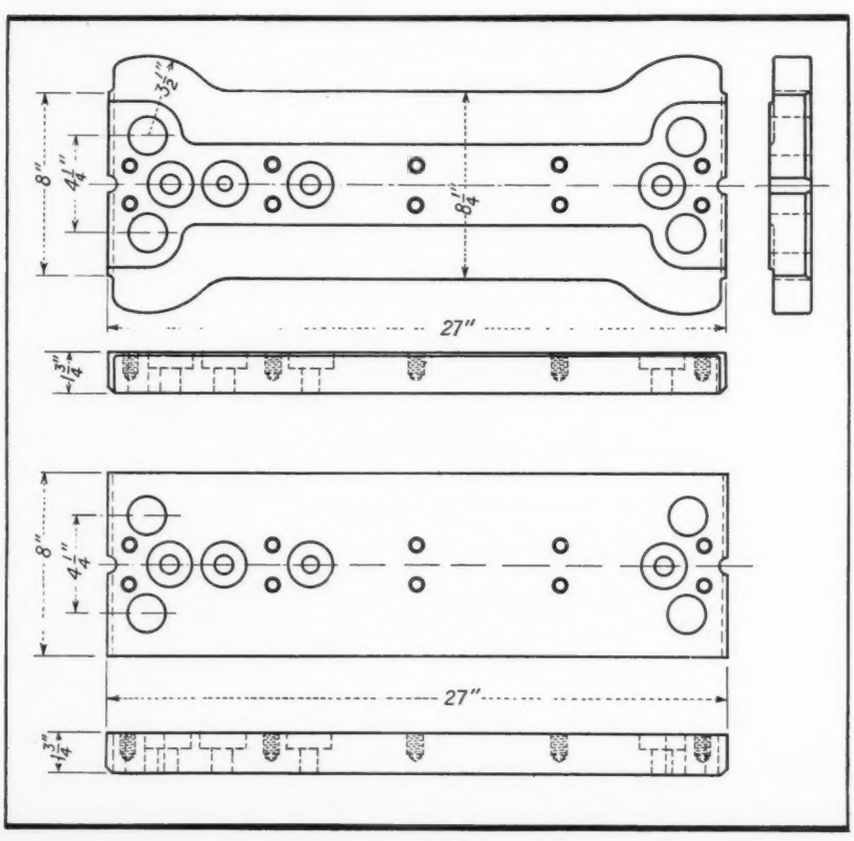

Crosshead
Added strut joins ribs over tension bolt
Steel and iron crossheads now have two ribs instead of one
Master connecting rod
Power connecting rods
Diameter increased from 6¾ to 8¼ in.
Scavenger piston
2¼ × ⅞ in. reinforcing flanges added on each side wall

Crosshead on the Cooper-Bessemer GMV compressor is another part in which Meehanite cast iron has replaced cast steel. One of the principal design changes is the addition of a tension bolt and a strut that tie the two side walls together and reduce any tendency toward buckling. The side walls are reinforced by 2¼ x ⅞-in. flanges encircling the cross-head pin. Both of these changes are indicated by lines superimposed on the reproduced photograph approximately to scale. The diameter of the end holding the scavenging piston was increased from 6¾ to 8¼ in. and similar thickening was made throughout. Both cast iron and newer cast steel crossheads have two symmetrically placed ribs instead of one on the sides, as shown.

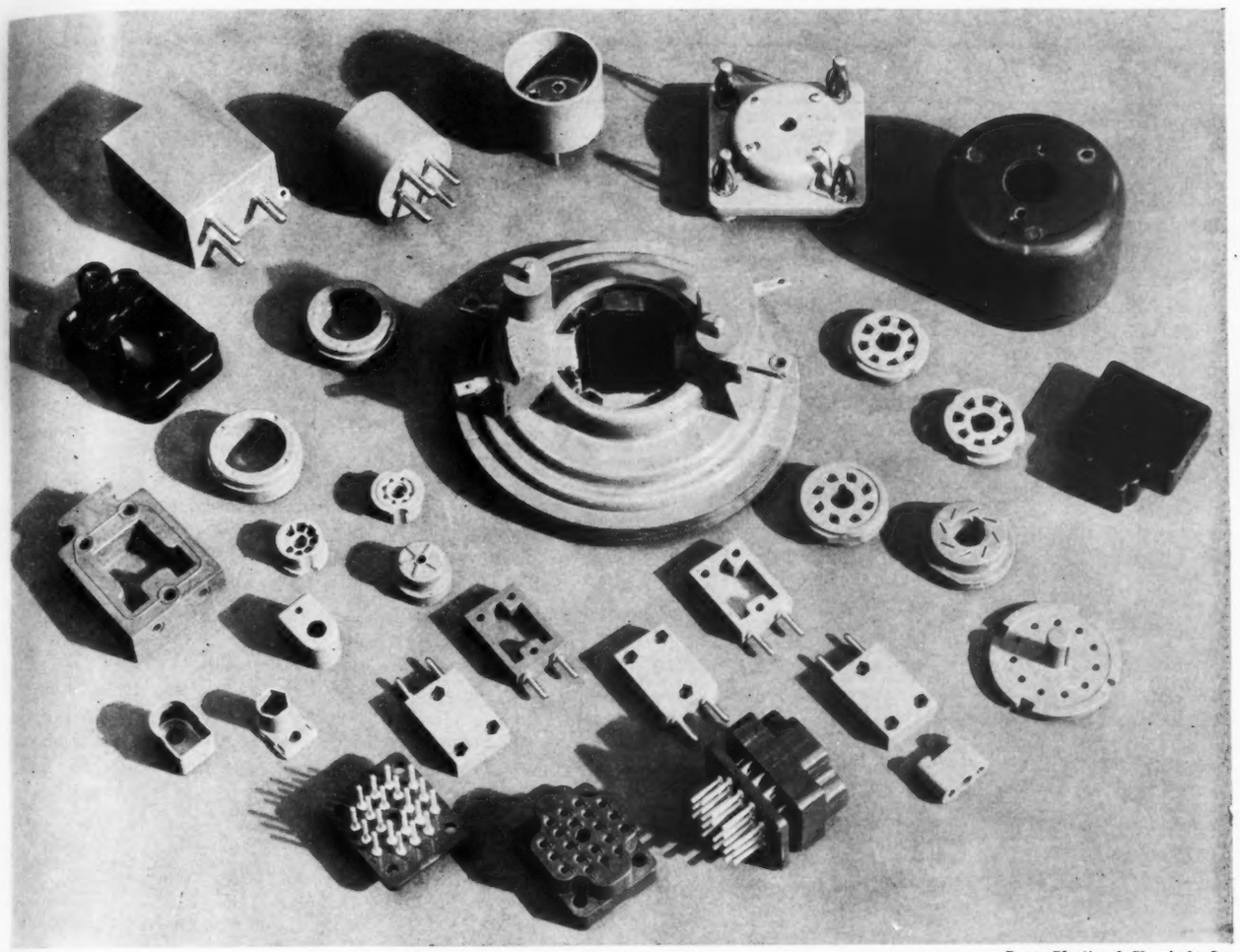
Sample crossheads were tested to destruction in the Ohio State University testing laboratory. R. L. Boyer, chief engineer of Cooper-Bessemer, Mt. Vernon plant, and his engineering staff were gratified to find slightly greater strength than their calculations indicated when it was designed.

The master connecting rod, which is shown with the crosshead, is made of cast steel. The design of this rod is obviously next to impossible to produce as a steel forging, as such rods are customarily made. Cast steel was decided upon at the time the engine was designed, before the war, and is also a good example of the dependability of castings when properly produced.

After being submitted to steel foundry engineers, who made certain modifications and recommendations for casting purposes, the rod was cast and cut into small sections to be analyzed from the foundry angle to insure sound castings. The elimination of defective castings in modern foundry practice is believed sufficient proof that correctly designed and produced steel castings are suitable for certain applications where steel forgings have been considered essential for reasons of superior strength. This rod is 34 in. between crankpin and crosshead pin centers and slightly over 4 ft. long.



These bars take a tension load in holding together the engine base, which is of jaw construction. They were originally of cold rolled steel but have now been replaced by Meehanite cast iron. Both old and new bars are shown. The cast bars' proportions were increased around the major bolting holes and the bar width was increased about 3 percent.



Durez Plastics & Chemicals, Inc.

Low power factor and arc resistance are important design considerations for these typical compression molded electrical parts

An Aid to Selecting Plastics For Electrical Applications

Dielectric strength, power factor, loss factor and insulation resistance are affected by temperature and humidity conditions which must also be considered when evaluating the various plastics materials for electrical applications. This article gives a quick comparative performance picture of the various types of plastics used in electrical design.

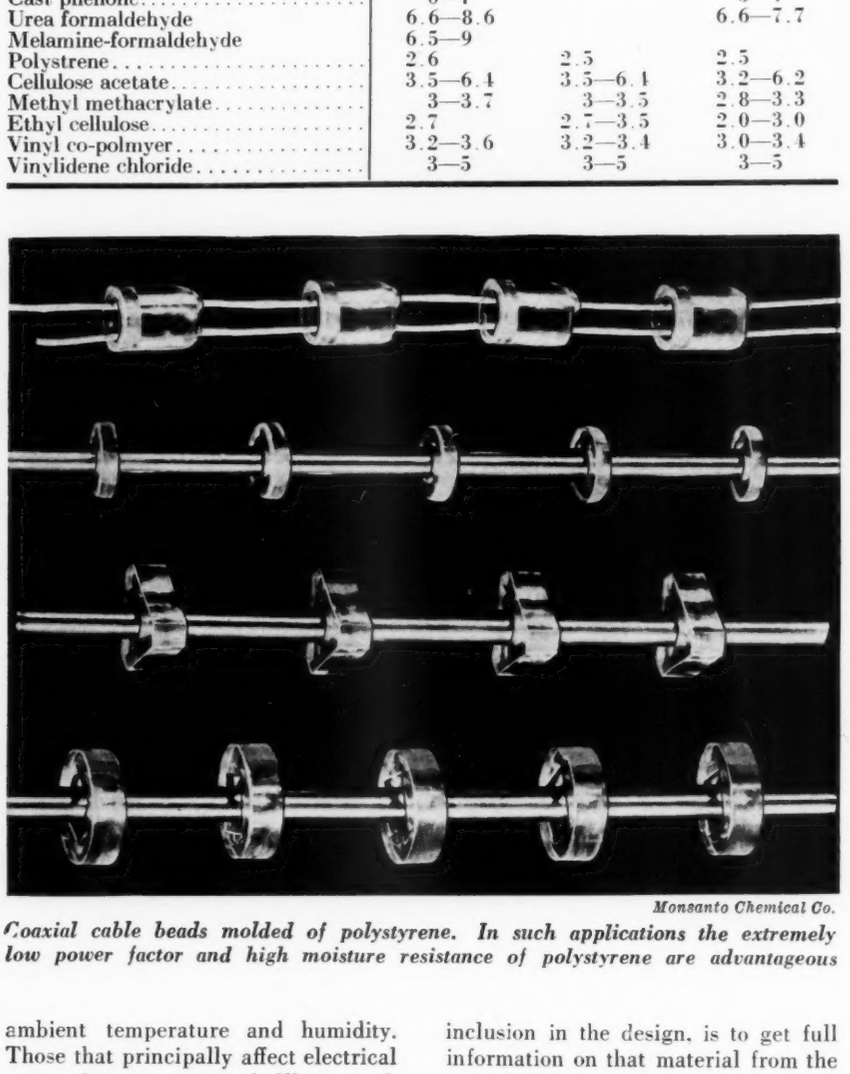
ADOPTION of plastics to electrical designs has been considerably accelerated by the development of new improved molding materials with superior electrical properties. Among these may be mentioned phenolics with special fillers, melamine-formaldehyde, polystyrene, ethyl cellulose and vinyl copolymers.

Naturally the choice of the right material for a given application will be reached through a series of compromises. This is true of the selection of any constructional material, but is particularly true for plastics. Thus the engineer must not only investigate physical and electrical characteristics; he must also study design limitations, production methods and cost. The physical and electrical characteristics will determine whether the material will withstand the required operating conditions. Design limitations relate to some extent to physical properties but they will depend to a degree on the production method which might be used, which in turn is selected on the basis of the cost of molds and tools, quantity of parts to be made and similar considerations. Thus the plastic material is evaluated in relation to both its adaptability and the total cost relative to that of other materials.

Many factors affect the properties of molded plastics; the method of compounding, types of fillers used, cure,

Table I—Dielectric Constants

Material	Dielectric Constant at Frequency of 60 cycles	10^3 cycles	10^6 cycles
Phenol formaldehyde			
wood flour filler	5—12	4—8	4.5—8
fabric filler	5—10	4.5—6	4.5—6
mineral filler	5—20	4.5—20	4.5—20
Phenol furfural	5	6—7.5	
Cast phenolic	6—7		5—7
Urea formaldehyde	6.6—8.6		6.6—7.7
Melamine-formaldehyde	6.5—9		
Polystrene	2.6	2.5	2.5
Cellulose acetate	3.5—6.4	3.5—6.1	3.2—6.2
Methyl methacrylate	3—3.7	3—3.5	2.8—3.3
Ethyl cellulose	2.7	2.7—3.5	2.0—3.0
Vinyl co-polmyer	3.2—3.6	3.2—3.4	3.0—3.4
Vinylidene chloride	3—5	3—5	3—5



Monsanto Chemical Co.

Coaxial cable beads molded of polystyrene. In such applications the extremely low power factor and high moisture resistance of polystyrene are advantageous

ambient temperature and humidity. Those that principally affect electrical properties are types of fillers used, ambient temperature and humidity conditions. The data presented in this article are of value principally on a relative basis for a given property. The values were obtained for the most part under standard A.S.T.M. test conditions. It cannot be assumed that a material which under standard test shows a dielectric strength of 250 volts per mil will show that same dielectric strength for a different thickness under different conditions of temperature and humidity. Comparative presentation does show for what property each material is best, and what compromise may be necessary. Hard and fast rules cannot be set down.

A good fundamental rule, after first studying a plastic material for possible inclusion in the design, is to get full information on that material from the manufacturer with particular reference to what test procedures were used by his laboratory to determine physical, chemical, thermal and electrical values. Also, consultation with an experienced molder before final design prints are made will repay the engineer in many ways. The molder knows how various materials will behave under fabrication and whether it is economically feasible to use the desired fabrication process. Further, he may be in a position to suggest slight changes in design that will speed production and may reduce cost.

Electrical properties of plastics in service depend to a great extent upon proper design, operating temperatures and conditions of humidity. Many times it will be possible by proper design to obtain better electrical performance of the part. High temperature adversely affects electrical properties. For example, dielectric constants change considerably with rise in temperature. Moisture also affects electrical properties: dielectric constants and power factor usually increase in proportion to the amount of water absorbed. Water absorption of some of the plastic materials may, to some extent, reduce surface resistivity and cause service failure.

Six characteristics are usually studied before specifying a plastic material for an application where electrical properties are of paramount importance. These are dielectric constant, dielectric strength, power factor, loss factor, insulation resistance and arc resistance. For each of these, standard A.S.T.M. test procedures have been devised.

Dielectric constant, or ratio of the capacity of a condenser with a given dielectric to its capacity with air as the dielectric, is usually measured at 60 cycles, 10^3 cycles, and 10^6 cycles. These constants are of particular importance in radio circuits. In Table I they are set up for comparative analysis; the values given are based on manufacturer's literature.

Table II—Dielectric Strength of Plastics

Short time test on 1/8-in. sample in volts per mil.

Material	Dielectric Strength at 10^6 cps in volts per mil.
Phenol formaldehyde	
wood flour filler	300—500
mineral filler	250—400
Phenol furfural	475—600
Cast phenolic	350—450
Urea formaldehyde	650—720
Melamine-formaldehyde	340
Polystyrene	500—700
Cellulose acetate	300—600
Methyl methacrylate	500
Vinyl co-polymer	100—500
Vinylidene chloride	500

Dielectric strength, or the maximum voltage that a material will withstand before puncture, divided by the thickness of the material, is expressed in volts per mil. Two factors seriously affect this measure: the rate of voltage increase and the thickness of the material under test. Three methods of testing are approved and have been standardized by the A.S.T.M. These are short-time test, step-by-step method, and endurance test. Of these, the easiest to apply and the most com-

Table III—Power Factor

Material	Power Factor at Frequency of 60 cycles per sec.	10^3 cycles per sec.	10^6 cycles per sec.
Phenol formaldehyde wood flour filled	0.04—0.30	0.04—0.15	0.03—0.1
fabric filled	0.08—0.30	0.08—0.20	0.04—0.1
mineral filled	0.10—0.30	0.10—0.15	0.005—0.1
Phenol furfural	0.1—0.02	0.10—0.15	0.005—0.1
Cast phenolic	0.10—0.15	0.04—0.15	0.04—0.1
Laminated phenolic paper base			0.02—0.08
fabric base			0.02—0.08
Urea formaldehyde	0.04—0.06		0.027—0.03
Melamine-formaldehyde	0.15—0.17		
Polystyrene	0.0001—0.0003	0.0001—0.0003	0.0001—0.0003
Cellulose acetate	0.01—0.06	0.01—0.06	0.01—0.05
Methyl methacrylate	0.05—0.07	0.06—0.07	0.015—0.03
Ethyl cellulose	0.007	0.005—0.025	0.007—0.03
Vinyl co-polymer	0.01	0.01	0.01
Vinylidene chloride	0.03—0.08	0.03—0.15	0.03—0.05

Table IV—Water Absorption

Material	Percent Water Absorption in 24 Hours
Phenol formaldehyde wood flour filled	0.2—0.6
fabric filled	0.5—2.5
mineral filled	0.01—0.3
Cast phenolic	0.4—0.5
Laminated phenolic paper base	0.3—9.0
glass fabric base	0.3—0.5
Urea formaldehyde	1.0—3.5
Melamine-formaldehyde	0.08—0.2
Polystyrene	0.0
Cellulose acetate	1.2—6.8
Methyl methacrylate	0.4—0.5
Ethyl cellulose	1.0—1.5
Vinyl co-polymer	0.05—0.15
Vinylidene chloride	0.0

monly used is the short-time test, where increasing voltage is applied at the rate of 0.5 kilovolts increase per sec. until puncture occurs. Material thickness is measured at point of failure. Dielectric strength is a function of temperature; the higher the temperature the lower the dielectric strength. With laminated plastics, tests parallel to laminations give lower dielectric strength. As frequencies increase, dielectric strength decreases.

Other factors that influence dielectric strength are fillers (mica-filled phenolics are high, graphite-filled low), manufacturing variables, exposure of material to high humidity. Table II shows the approximate dielectric strengths available in materials customarily considered for electrical applications.

Power factor, or ratio of power loss in watts to the voltage-amperes through a capacitor in which the material is the dielectric, is important in the design of radio frequency insulators. Moisture absorbing characteristics of the materials are important, as the power factor may change with absorption of water. For this reason, polystyrene has attained wide acceptance in the electrical field; its moisture absorption is practically zero.

Phenolic materials of the "low-loss" type have mica-fillers and are carefully dehydrated, but they cannot compare with the polystyrene which has a power factor of 0.001 at 60 cycles. Ethyl cellulose shows up well in this test, and is reported with a power factor of 0.0007 at 60 cycles.

Loss factor, or the product of power factor and dielectric constant may be of help in comparing materials, since it gives an idea of the heat generation rate per unit volume at certain test conditions.

Insulation resistance of plastic materials is fairly high and ranges from 10^{18} ohms per cm. for polystyrene to 10^{10} for phenolic. Surface conditions will affect the insulation resistance, as will moisture and high temperatures. Moisture and temperature are particularly critical. Here again, the engineer will do well to make careful tests before proceeding too far. The A.S.T.M. has devised tests to be made under certain specified conditions of temperature and humidity. These will serve as a good measure of the materials' ability *at the temperature and humidity condition of the test.* As to behavior at elevated temperatures, further testing and the experience of others are the only guides available. Much work has been done on this subject, and the engineer will do well to consult with manufacturers before proceeding too far with his design.

Arc resistance is a measure of the behavior of the material under a power arc, to determine the amount of carbonization or "tracking." This property will have to be determined by separate tests, under procedure devised by the A.S.T.M. It is important to consult the manufacturer if arc resistance is a requisite of the design. Arc resistance is of particular importance in switch design. Proper engineering can do much to reduce the danger of "tracking."

The amount of moisture absorbed in service will affect dielectric qualities, appearance, and sometimes dimension of the molded part. Polystyrene and vinylidene chloride show the best moisture resistance, the cellulose acetates behaving poorly in this respect. Some of the laminated phenolics are especially compounded for lower water absorption to obtain better electrical properties in the finished design.

Table V—Electrical Properties of Laminated Phenolic

Based on N.E.M.A. Standards

N.E.M.A. Grade of Phenolic Laminate	Power Factor at 10^6 cycles per sec.	Power Factor at 10^8 cycles per sec.	Dielectric Constant at 10^6 cycles per sec.	Dielectric Constant at 10^8 cycles per sec.	Dielectric Strength Volts per mil Short time	Dielectric Strength Volts per mil Step by Step	Water Absorption 24 hr.—percent (Sample 3″x1″x1/16)
X	.....		.....		700	500	4.0
P	.....		.....		700	500	3.0
XX	0.010	0.062	5.0	4.3	700	500	1.3
XXP	0.040		5.0		700	500	1.3
XXX	0.032		4.8		650	450	1.0
XXXP	0.027	0.045	4.5	3.8	650	450	1.0
C	0.10		7.0		200	120	3.0
CE	0.055	0.055	5.5	4.0	500	300	1.5
L	0.10		7.0		200	120	2.0
LE	0.045		5.0		500	300	1.2

Stress Concentration Factors And Their Effects on Design – II

GEORGE H. NEUGEBAUER
Department of Machine Design, Cooper Union School of Engineering

Stress concentration factors that can be applied to members subjected to fatigue have been correlated from the work of numerous investigators and presented with a thorough discussion of their applications and limitations. Seven cases are added to the 31 given last month, which were determined by various methods and were applicable where fatigue is not a factor.

IT HAS BEEN found that the strength of members made of reasonably ductile materials and subjected to steady loads or only a few cycles of repeated loads are little affected by stress concentrations resulting from fillets, holes, notches or other stress raisers. This apparent immunity is caused by yielding at the point of high localized stress, which redistributes the load over the section. On the other hand, members made of brittle materials, other than gray cast iron, and subjected to steady loads are definitely weakened by stress concentrations. However, members made of either ductile or brittle materials when subjected to repeated loads have their strength reduced by stress concentrations, and the breaks have the appearance of brittle fractures with little evidence of yielding at points of high localized stress.

It has also been found that the endurance limit of plain polished specimens without stress concentrations are nearly independent of the geometric size or grain size but are dependent only on the material with a very good correlation of endurance limit with ultimate strength. The endurance limits of almost all wrought ferrous metals are from 40 to 60 percent of their ultimate strengths. For most cast irons and cast steels the endurance limits are from 30 to 50 percent of the ultimate strengths while for the non-ferrous metals endurance limits range from 25 to 50 percent of the ultimate strengths.

In the previous article in February PRODUCT ENGINEERING the writer gave the stress-concentration factors as determined by the theory of elasticity, photo-elastic measurements, and strain measurements. In this article the effect of stress concentrations on members subjected to fatigue are given.

Stress-Concentration Factors in Fatigue

Since the stress at the edge of a small hole in a very wide plate in tension or compression is three times the average stress, it might reasonably be expected that the endurance limit under reversed axial loads would be only one-third the endurance limit of the solid plate, but this is not always true. The ratio of endurance limits of a plain specimen and a specimen with stress concentration may be called the effective stress-concentration factor in fatigue.

Let k= theoretical stress concentration factor as determined by photoelastic or other measurements.

Let k_f=stress-concentration factor in fatigue, defined as:

$$k_f = \frac{\text{endurance limit of plain specimen}}{\text{endurance limit with stress concentration}} \qquad (1)$$

Until comparatively recent years it had been customary to use small specimens 0.25 in. to 0.50 in. in diameter to determine the effect of stress concentrations on fatigue specimens. The effective stress concentration factors thus obtained were found to be considerably less than the theoretical stress-concentration factors. When larger specimens were tested in fatigue, it was found that the value of k_f approached the value of k as the size of the specimen was increased. In Fig. 1 are shown the fatigue stress concentration factors obtained by Peterson and Wahl (Ref. 1) for shafts with fillets in pure bending. Fig. 2 shows their results for shafts with transverse holes under pure bending. It is seen that the stress concentration factors in fatigue, k_f, approach the theoretical stress concentration factor k with increase in size.

Other tests with different types of stress-raisers have demonstrated the same size effect. That there should be a size effect is not surprising when it is considered that both the theory of elasticity and photoelastic tests are dealing with homogeneous isotropic materials while engineering materials are neither homogeneous nor isotropic except in a statistical sense. The peak stresses due to stress raisers act over a comparatively small number of grains, particularly in a small specimen, and these grains are not homogeneous nor isotropic. For much the same reason it is reasonable to expect that the finer the grain size, the more a specimen of a given size will act like an isotropic material. Then the value of k_f should be closer to the theoretical stress concentration factor k for a fine-grained material than for a coarse-grained material. This effect is shown in Figs. 1 and 2 by the fine-grained nickel-molybdenum steel as compared with the coarser-grained carbon steel.

The high or peak stresses due to stress-raisers are usually confined to a small region. In a wide plate in tension with a small transverse hole, the stress concentration factor is 3.0 at the edge of the hole, but at a distance of twice the radius of the hole it is 1.22, while it is only 1.075 at a distance of three times the radius. Here the effect of the stress peak is felt by a comparatively few grains around the boundary of the hole and these few grains are not even statistically isotropic. It has been qualitatively proven that highly stressed material will act more like an isotropic material when the stress gradient per grain is small than when the stress gradient per grain is large. This is shown in Figs. 1 and 2 in which the fine-grained nickel molybdenum steel with a low stress gradient per grain has a value of k_f closer to the theoretical stress concentration factor for a given diam-

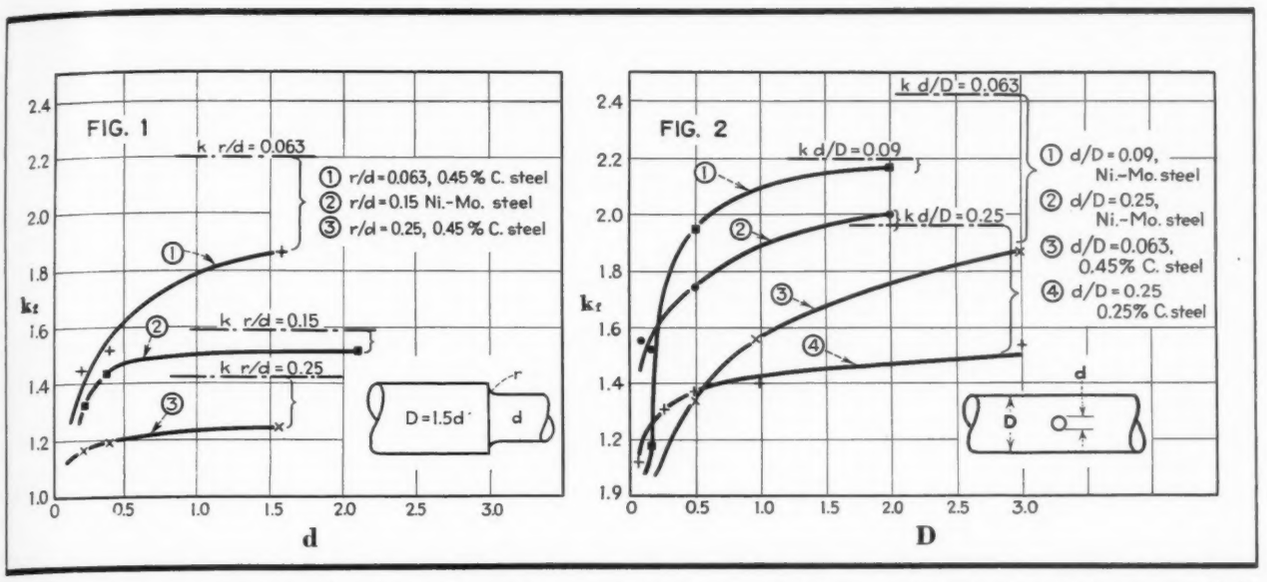


Fig. 1—Fatigue stress concentration factors for shafts with fillets in pure binding, as determined by Peterson and Wahl. Fig. 2—Fatigue stress concentration factors for shafts with transverse holes under pure bending, as determined by Peterson and Wahl, approach theoretical factors with increase in size

eter than the coarser grained medium carbon steel, which has a high stress gradient per grain. Of course the value of this stress gradient per grain will depend not only on the size of the specimen and the grain size but also on the type of stress raiser. For some types of stress-raisers the stress concentration is extremely localized and for others the effects are more widely felt.

Thus, the effective stress-concentration factor in fatigue is seen to be affected by at least four variables: (1) material, (2) geometric size, (3) grain size, and (4) stress gradient. From a study of these factors, Peterson and Wahl (Ref. 1) made the following observations:

(a) In some instances the stress concentration factors in fatigue were found to be quite close to the theoretical stress-concentration factors.

(b) Fatigue results for the fine-grained alloy steels and quenched carbon steels are usually closer to theoretical results than are the corresponding fatigue results for the coarser grained unquenched carbon steels.

(c) Stress concentration factors in fatigue decrease with size of specimen and for very small specimens the fatigue factor is nearly unity.

(d) Effective stress concentration factors in fatigue that are determined for small specimens should not be applied to the design of machine parts without regard to size.

A solution of the problem has not been attained but the gradient method developed by Peterson (Ref. 2) gives at least an indication of the geometric size and grain size effect. Most design problems do not permit full scale fatigue tests because of expense, lack of time, or lack of equipment, and in such instances the method outlined in his paper will prove useful until a better approach is suggested.

Practically all values of k_f have been found to be less than or at most equal to the theoretical stress-concentration factor. This gives at least the upper limit of k_f regardless of material, geometric size, or stress gradient. There have been a few apparent exceptions to this rule, notably in press fits, but there has always been another agent at work. In the case of press fits there is the effect of fretting corrosion due to the small movements between the members, which greatly reduces the fatigue strength of the fit.

The values of the stress-concentration factors in fatigue that follow were mostly determined on small specimens. Unless otherwise noted it must be kept in mind that these factors may be too low for larger or finer grained members. For Cases I to XXXI, see February P.E.

CASE XXXII—CIRCULAR SHAFTS WITH KEYWAYS IN BENDING. (Ref. 3, 4, 5, 6)

R. E. Peterson (Ref. 3) tested shafts made of normalized medium-carbon steel and of heat-treated chromium-nickel steel with both sled-runner keyways and profiled keyways (Pratt and Whitney type). The fatigue test specimens were of the cantilever type, one inch in diameter with keyways ¼ in. wide and ⅛ in. deep. The sled-runner keyways were cut with a 1½-in. diameter cutter.

The stress concentration factors in fatigue are given in Table I. Values in column (A) are based on section modulus of the solid shaft and are useful to designers. Those in column (B) are based on net section, assuming linear stress distribution, and are of interest to investigators of stress concentration effects.

Table I — Stress Concentration Factors in Fatigue for Keyways

Endurance Limit =	k_f (A)	k_f (B)
Chromium—Nickel Steel 58,000 lb. per sq. in.		
Sled runner keyways	1.61	1.35
Profiled keyways	2.07	1.74
Medium—Carbon Steel Endurance Limit 37,000 lb. per sq. in.		
Sled runner keyways	1.32	1.11
Profiled keyways	1.61	1.35
¼-in. transverse hole	3.06	1.76

The theoretical stress-concentration factor for a transverse hole in bending, as given in Case XXVIII with a ratio of hole diameter to shaft diameter of one to four ($\frac{d}{D}=\frac{1}{4}$), is 1.95 for the net section as compared with the value of 1.76 obtained for the one-inch medium-carbon steel shaft. From a study of the values of k_f given for the

two steels, the results would indicate that the values of k_f obtained for the chromium-nickel steel are very close to the theoretical stress concentration factors and may be used as the basis for the design of larger shafts with keyways. It can be concluded that the sled-runner type of keyway is preferable to the profiled type from the standpoint of fatigue. The former has an endurance limit approximately 30 percent higher than the profiled keyways for the chromium-nickel steel or the one-inch diameter specimens.

Seely and Dolan (Ref. 4) obtained the same qualitative results for the stress concentration factors for sled-runner and profiled keyways by means of the plaster-model method. The sled-runner keyway was found to be about 20 percent stronger than the profiled keyway. This increase is about the same as Peterson obtained for the medium-carbon steel. The values obtained by Thum (Ref. 5) are also consistent with Peterson's results.

Cold working of keyways (Ref. 6, p. 155) offers interesting possibilities. Wiecker and Koch found a 20 percent improvement by surface rolling the shaft before cutting the keyway and peening or cold rolling the corners of the keyway groove.

CASE XXXIII—CIRCULAR SHAFTS WITH KEYWAYS IN TORSION (Ref. 4, 6, 7, 8)

Shafts having keyways are sometimes subjected to alternating torsion as in the case of reciprocating engines. Researches have shown that the ratio between torsion and tension yield points, 0.575, holds also for endurance limits within about 6 percent and further that the same relationship holds for torsion and bending fatigue tests involving stress concentration. This means that for the cases investigated (Ref. 8) the stress concentration factors were the same for bending and torsion. Until further data are available, the factors given in Table I might be used in design for both bending and torsional fatigue applications. However, the data of Seely and Dolan (Ref. 4) do indicate that the stress concentration factors in torsion are about 15 to 20 percent higher than those for bending.

Fractures generally start near one end of the keyway about at the junction of the straight part of the keyway and its rounded tip. The localization of stress is caused not only by the sharp radius in the keyway but also by localized pressure resulting from the sharp corner of the key. To distribute this pressure more evenly, and to relieve some of the load at the junction of keyway body and ends, Fopple suggests making the key springy at the ends. (Ref. 6. p. 156). He experimentally showed appreciable improvement by this variation.

G. S. von Heydekampf (Ref. 7) cited a case where torsional fatigue failure occurred near the tip of a keyway when a steel key was used but was prevented by substituting a copper key. His explanation was that the key deformed elastically sufficiently to distribute the stress.

CASE XXXIV—SCREW THREADS IN TENSION AND BENDING (Ref. 6, 9, 10, 11, 12, 13)

Comparatively few tests have been made on the fatigue strength of screw threads and these have all been on $\frac{5}{16}$-in. and $\frac{3}{8}$-in. specimens.

Moore and Henwood (Ref. 9) made axially repeated tensile tests on $\frac{3}{8}$ in.-16 pitch U. S. Standard (National Coarse) and on $\frac{3}{8}$ in.—16 pitch Whitworth threads, the results of which are given in Table II. The writer has recalculated the values of k_f in accordance with the well accepted theory of failure (Ref. 13) defined by

$$\frac{\sigma_a}{\sigma_n} = \frac{k_f \sigma_a}{\sigma_e} = 1$$

Where

σ_n = nominal mean stress

σ_a = nominal amplitude of the variable stress

σ_u = ultimate tensile strength

σ_e = endurance limit with complete reversals of stress

k_f = stress concentration factor in fatigue

This theory appears to be reasonable because the value of fatigue strength for polished specimens subjected to repeated zero-to-maximum pulls fell almost exactly on this line when the endurance limit was taken as approximately one-half the ultimate strength.

These threads were not engaged and therefore did not show the effects of tightness of fit. High strength steel (S.A.E. 2320) did not give a proportionate increase in fatigue strength because the stress concentration factor, as a result of fine grain, increased as fast as the ultimate strength, particularly for the Whitworth thread. This would indicate that experimentally determined stress concentration factors for nickel steel are close to theoretical values. The increase in the fatigue strength of the rolled threads, presumably National Coarse threads, is caused partly by slight cold working and may be caused partly by the fact that the rolled threads extended the full length of the specimen while the cut threads had only one or two threads exposed on the ends. No tests were made with rolled threads on nickel steel.

Table II—Screw Threads in Tension

Medium Carbon Steel Ultimate strength = 57,400 lb. per sq. in.	k	k
$\frac{3}{8}$ 16 National thread	3.7	5.62
$\frac{3}{8}$ 16 Rolled National thread	2.7	5.62
$\frac{3}{8}$ 16 Whitworth thread	2.1	3.86
S.A.E. 2320 Nickel Steel Ultimate strength = 109,000 lb. per sq. in.		
$\frac{3}{8}$ 16 National thread	5.3	5.62
$\frac{3}{8}$ 16 Whitworth thread	4.5	3.86

Table III—Screw Threads in Bending

Type of Specimen	Ult. Strength	k_f	k
(A) S.A.E. 3140, Ni-Cr. Steel			
5/16—18 National	143,000	2.68	5.62
5/16—18 Aero	143,000	1.85	—
(B) Medium Carbon Steel			
$\frac{3}{8}$—24 National cut	89,300	1.89	5.62
$\frac{3}{8}$—24 National, single extrude and rolled	89.300	1.54	5.62
$\frac{3}{8}$—24 National, double extrude and rolled	77,400	1.34	5.62

All stress concentration factors in Tables II and III are based on root area. Theoretical stress concentration factors k were obtained by Hall (Ref. 10) in photoelastic tests. They are, however, of doubtful validity for a fitted screw thread.

R. R. Moore (Ref. 11) conducted tests on engaged screw threads under completely reversed stresses in bending. Two types of threads were tested, the $\frac{5}{16}$—18 National Coarse thread and the $\frac{5}{16}$—18 Aero-thread. His results

are shown in Table III(A).

A. M. Smith (Ref. 12), in comparing cut and rolled threads, found that single extruding and rolling threads increase ultimate tensile strength and fatigue strength while decreasing tension impact strength slightly. Double extruding and rolling threads increases ultimate tensile and fatigue strength the most and reduces tension impact strength the most. Unfortunately, Smith did not find the endurance limit for plain polished specimens so that values of k_f given in Table III(B) were calculated on the basis of an endurance limit equal to one-half the ultimate strength of the plain, unworked wire. Values of k_f were also calculated on the basis of root area, instead of a mean area as given in Smith's paper, and on the endurance limit of the original wire before rolling or extruding. The theoretical stress concentration factors k were obtained by Hall (Ref. 10) in tension.

Stress concentration factors do not tell the whole story because the shape at the root of the thread must also be taken into consideration. Moore and Henwood (Ref. 9) and R. R. Moore (Ref. 11) both used sharp roots while Smith (Ref. 12) used fillets at the roots, which is more usual. Hall's values of k (Ref. 10) are also for sharp threads. It would, however, be dangerous to use stress concentration factors k_f given in Table III(B) for larger screws or finer grained material.

It is also necessary to take root area as well as stress concentration factor into account. When this is done, it is found that the $\frac{5}{16}$—18 Aero-thread is nearly 2½ times as strong in fatigue as $\frac{5}{16}$—18 National Coarse thread instead of 1½ times as indicated by stress concentration factors alone.

Photoelastic studies show that stress concentration around a notch can be affected by putting in an adjacent notch. This mutual interference is noted in screw threads so that a single circumferential groove has a worse effect than does a continuous thread of the same shape and depth. At the end of the thread there is no stress-interfering groove, so the weakest place in a thread is at its end; therefore, a bolt that is completely threaded is stronger in fatigue than one threaded only on part of its length. Cutting away the bolt diameter to less than that at the base of the thread and having this cut come to the end of the thread is helpful. This method does away with the combination of end thread stress and clamping stress.

CASE XXXV—CIRCULAR SHAFTS WITH TRANSVERSE HOLE IN BENDING

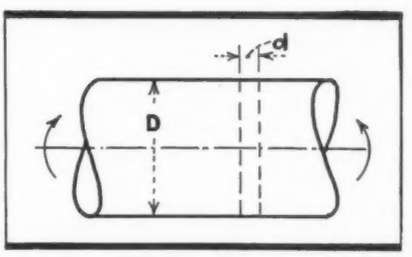
The results obtained by Peterson and Wahl (Ref. 1) on transverse holes in a shaft under pure bending in fatigue has already been shown in Fig. 2, while the theoretical stress-concentration factors were given in Case XXVIII.

The effect of transverse holes in specimens 0.330 in. in diameter for an aluminum forging alloy (25ST) and for a magnesium-zinc-aluminum forging alloy were investigated at Wright Field (Ref. 6, pp. 65-6). The results are shown in Table IV, with both the fatigue and the theoretical stress concentration factors given.

Thum and Bantz (Ref. 6, pp. 146 and 156) showed that pressing stress-relieving depressions around an oil hole improved the fatigue strength of the member more than machining these additional stress raisers. Doring (Ref. 6, p. 156) studied the effect of pressing a Brinnell ball into the hole and then rounding off the ends of the bored hole by polishing out the irregularities thus produced. Rounding off the edges so that the burr is removed was found to be very important. Countersinking and polishing the edges were preferred to pressing in a ball because of difficulties in polishing the bore thereafter.

Table IV—Stress Concentration Factors for Circular Shaft With Traverse Holes in Bending

D/d =	12	6	3
k =	2.3	2.09	1.85
25 ST, k_f =	2.26	1.93	1.47
Mg-Zn-Al, k_f =	2.50	2.00	1.43

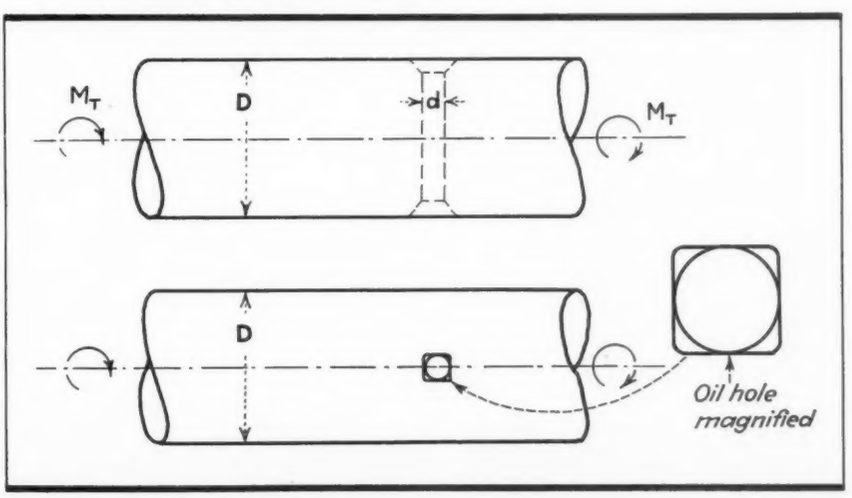


CASE XXXVI—CIRCULAR SHAFTS WITH TRANSPERSE HOLE IN TORSION

Thum and Weiss (Ref. 6, p. 157) made a punch in the form of a square pyramid with edges rounded off on a large radius. This was then pressed into the oil hole of a shaft under pressure regulated according to the hardness of the steel, taking pains not to produce as much hardness in a hard

Table V — Stress Concentration Factors of Oil Holes in Shafts

Endurance Limit in Torsion After Polishing	Bored Hole	Bored Square Hole, and pressed polished lips
	k_f	k_f
36,000	1.85	1.16
37,500	1.56	1.17



steel as in a softer one and to avoid over cold working. The burr was then polished off and the lip of the hole, now in the shape of a square with rounded corners, was also polished. The square was in line with the axis of the shaft, so that the strongly worked corners were at 45 deg. to the axis and the slightly worked sides of the square were respectively in line with, and normal to, the axis, since these shafts were being prepared for use in torsion, where the maximum normal stress comes at 45 deg. They then tested the specimens with the rounded square impression in the ends of the oil hole under reversed torsion using steel heat-treated to two hardness levels. Their results are shown in Table V.

There have been a number of failures in shafts that were polished but had a rough place in the drilled hole, which acted as a nucleus for failure.

CASE XXXVII—FLAT PLATES WITH TRANSVERSE HOLES IN TENSION (Ref. 6)

Basner (Ref. 6, p. 66) made axial stress fatigue tests of a steel of 84,000 lb. per sq. in. in ultimate tensile strength and 53,500 lb. per sq. in. yield strength in which the stress varied from a low tensile load to a higher load four times as great. A stress range at which 10,000,000 cycles were withstood without fracture was taken as the endurance limit. Flat specimens 0.87 in. wide by 0.65 in. thick with 0.2 in. hole bored through the wide face were used in one series of tests. The hole was left with either a normal drilled hole, or internally polished, or the edges of the hole rounded off by counter-sinking slightly and the hole and edges polished.

Table VI—Stress Concentration Factors in Flat Plates With Transverse Holes in Tension

	k	k
(a) Bored Hole, not rounded nor polished	2.2	2.42
(b) Hole polished, edges left sharp	1.93	2.42
(c) Hole polished, edges rounded and polished	1.83	2.42

The fatigue stress concentration factors k_f were obtained by the use of Equation (1) while the theoretical stress concentration factors were obtained from Case V. See Table VI.

CASE XXXVIII—EFFECT OF WORKSHOP FINISHES ON FATIGUE STRENGTH

Much experimental work has been done to evaluate the effect of different workshop finishes, but it has not yet been reduced to a form which can be used with any great confidence.

Thomas (Ref. 14) and Moore and Kommers (Ref. 15) were among the first to show the deleterious effect of the usual workshop finishes. These experiments showed that the stress concentration factor for a smooth turned shaft under pure bending is about 1.2 while the stress concentration factor for a ground surface is about 1.1 and for an emery polished surface about 1.06. However, these experiments were made on specimens less than ½ in. in diameter and would therefore probably be unsafe to use on a larger shaft. Horger (Ref. 16) found a stress concentration factor of 1.9 for a smooth turned 6-in. shaft.

Surface rolling and shot blasting, as shown by Ref. 17, 18, 19, 20, 21, and 22, have a beneficial effect on the fatigue strength of metals on account of the cold working effect.

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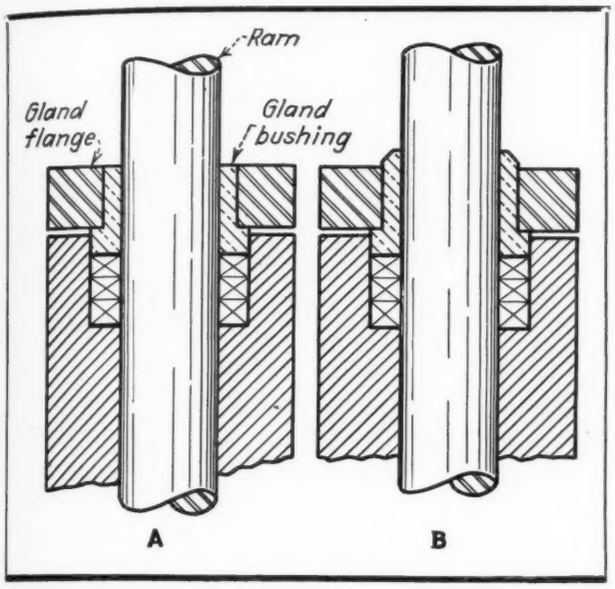
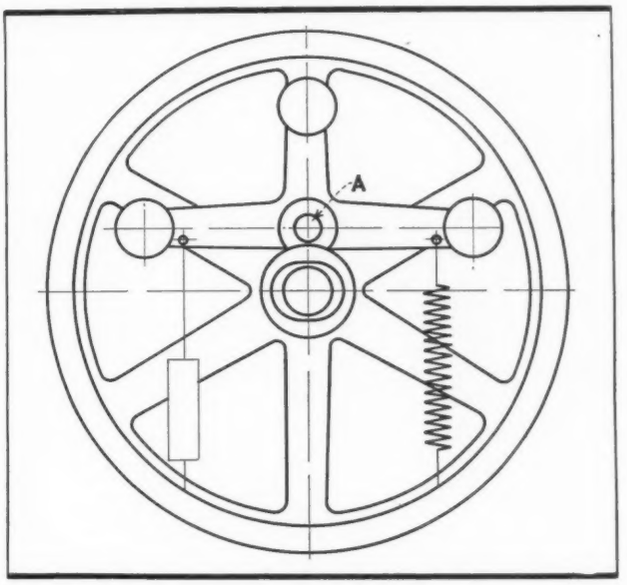
(22) Discussion on above, March, 1927.

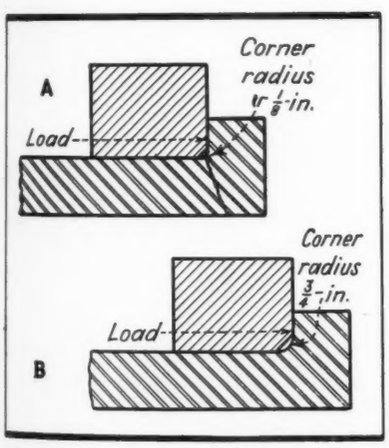
Causes and Cures



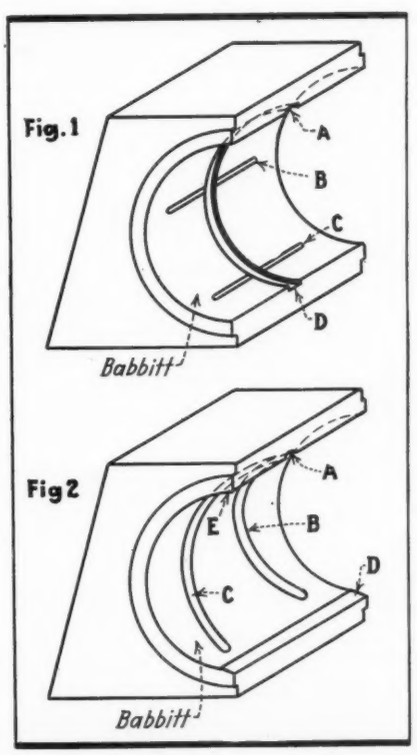
Hydraulic ram acting vertically, as shown at *A*, scored badly after short use. It was found that oil leaking through the gland formed a stagnant puddle on the top flat surface of the gland flange. This oil collected dirt which was drawn down through the gland bushing on the down stroke of the ram, thus scoring the ram. The condition was cured by extending the bushing through the gland flange as shown at *B*, so that leakage flowed away from the ram.



Inertia governor caused erratic operation even though the engine had been thoroughly checked and keyed up perfectly several times. The governor, of the inverted type, swung on a roller bearing carried by pin *A*. After it was noticed that the rollers had marked the races, thus indicating an overload, the roller bearing and old pin were replaced with a new pin and a phosphor bronze bushing. After this, the governor regulated easily at all speeds.



Lug under repetitive shock load failed, as shown at *A*, after a few months service. The piece was redesigned increasing the corner radius from ⅛ in. to ¾ in. as shown at *B*. This radius was also highly polished. Despite higher bearing pressure and an apparent increase in bending moment because of the greater eccentricity of load application, the new design has given no failures so far.



Oil grooves cut in engine crankpin bearing as shown in Fig. 1 worked satisfactorily while the bearings were new. Oil fed in at *A*, in flowing around to *D*, branched off into grooves *B* and *C*. As the crankpin and bearing began to wear, a ridge formed on the crankpin under the groove *AD*, thus diminishing the oil carrying capacity of the groove. When the bearing was keyed up to reduce the slack, the ridge in running against the edges of the groove produced extra friction causing the pin to run hot. The ridge also prevented any pinching of the connecting rod sideways so that it was impossible when keying up the brasses for one to judge what the clearance was. All these troubles were corrected by removing the ridge from the crankpin, rebabbitting the brasses and cutting the grooves *B* and *C* spirally as shown in Fig. 2; in addition at *D* and *E* slight reliefs were cut.

PRODUCT ENGINEERING will pay a minimum of $3 for each example published in Causes and Cures. Where illustrations are necessary, include drawings, rough sketches or photographs.

ADHESIVE APPLICATORS FOR

METHODS OF APPLYING LIQUID ADHESIVES that are illustrated here are a continuation of the methods given last month. This group includes rotary applicators on movable axes and otherwise movable between adhesive pick-up position and applying position, endless belt applicators, applicators in the form of moving daubers, plates, and the like, reciprocating dies exuding measured quantities of cement, and spray nozzles. All of these mechanisms are used or are applicable on production machines such as for making pasteboard boxes or cartons, pasting labels or envelopes, and making shoes or other products involving the use of liquid adhesives.

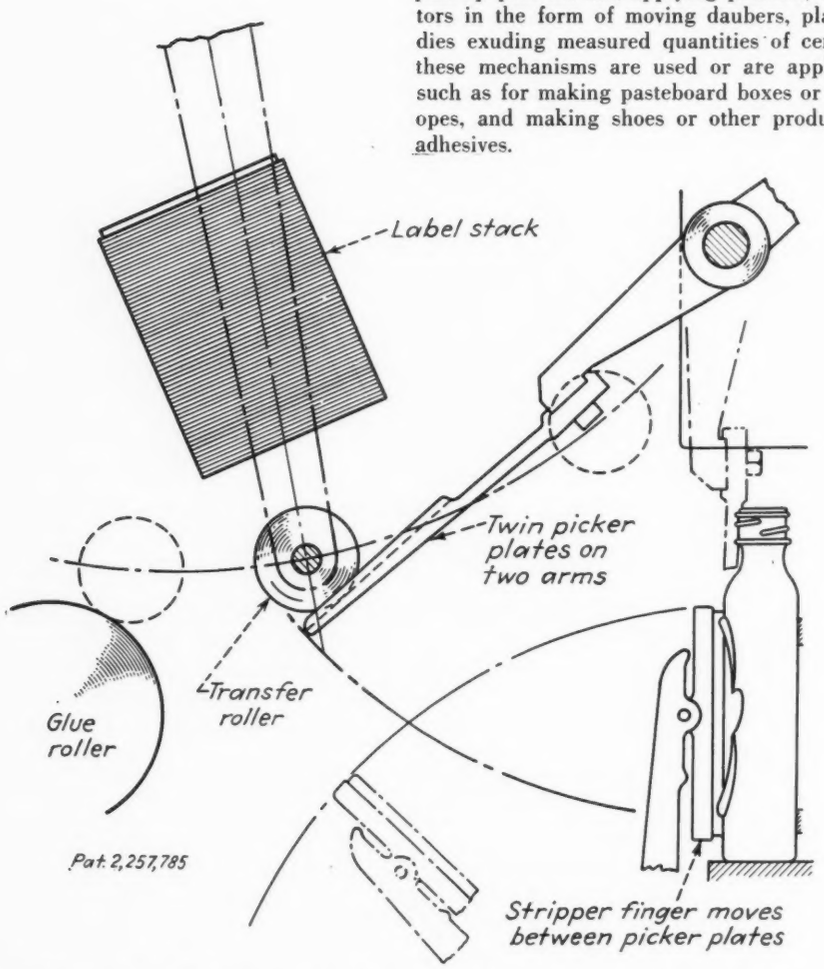


FIG. 1 – *Bottom label is spread with glue by two abutting glue-coated picker plates, which separate during contact with label stack, then carry label to bottle*

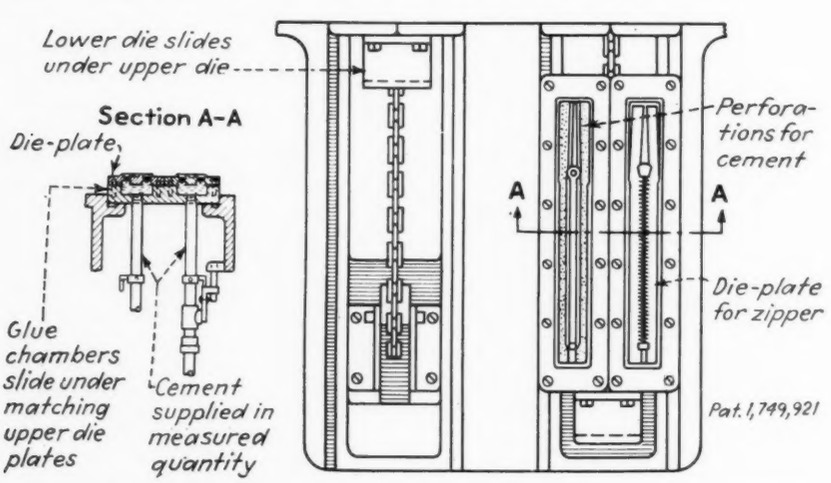


FIG. 2 – *Measured quantities of cement are forced through perforations in specially designed upper and lower die plates, which are closed hydraulically over zippers. Lower die only is shown*

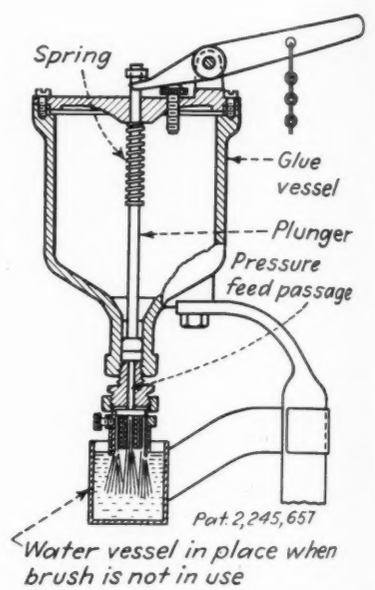


FIG. 3—*Brush applicator is fed through passages between bristle tufts by spring operated plunger*

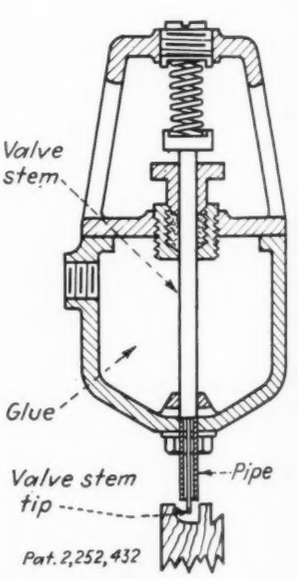


FIG. 4—*Shoulder on valve stem in glue chamber retains glue until pressure on tip opens bottom valve*

HIGH-SPEED MACHINES – II

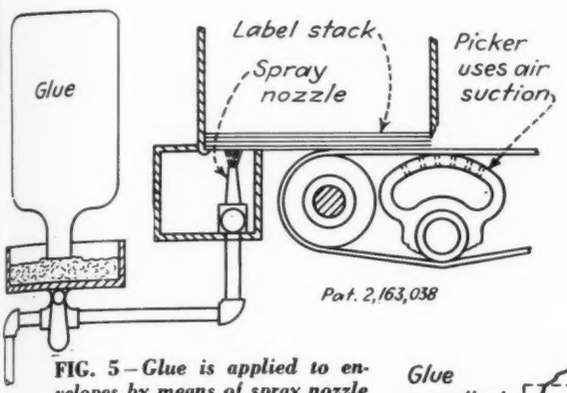


FIG. 5 – *Glue is applied to envelopes by means of spray nozzle*

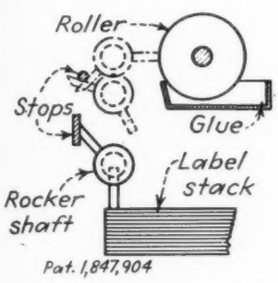


FIG. 6 – *Rocker shaft on rack, which is moved vertically by sector gear, carries glue on contact bar from roll to label stack*

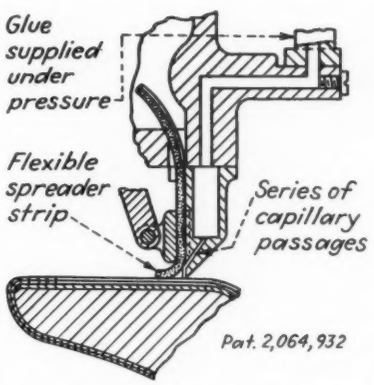


FIG. 7 – *Glue is extruded through nozzle on work*

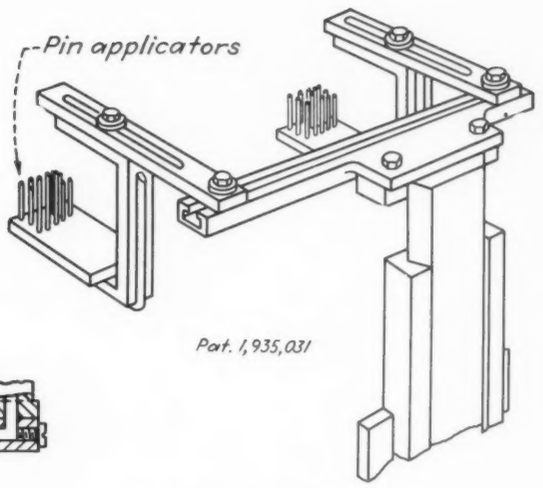
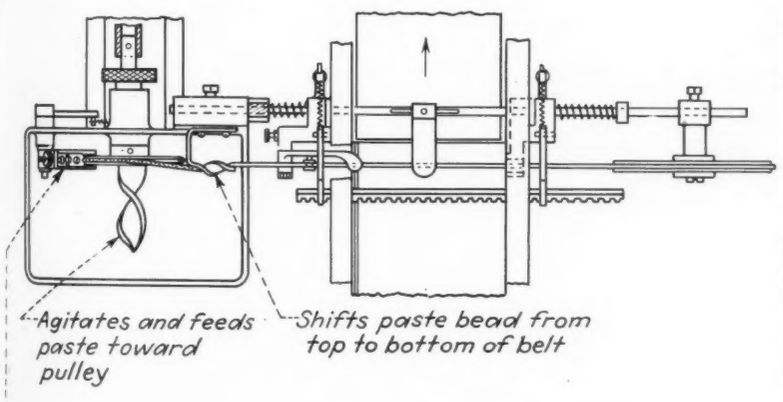


FIG. 8 – *Pin applicators reciprocate vertically, first immersing in glue, then contacting underside of carton flaps in desired pattern*



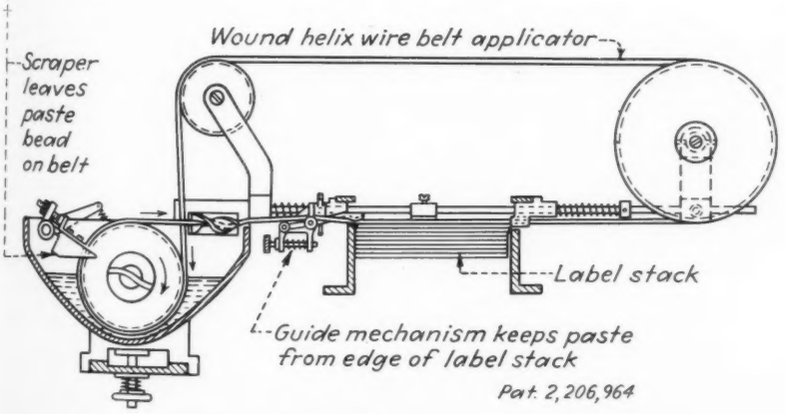

Wound helix wire belt applicator
Scraper leaves paste bead on belt
Label stack
Guide mechanism keeps paste from edge of label stack
Pat. 2,206,964

FIG. 9 – *Paste belt applicator passes around pulley in pastepot and slides over label stack*

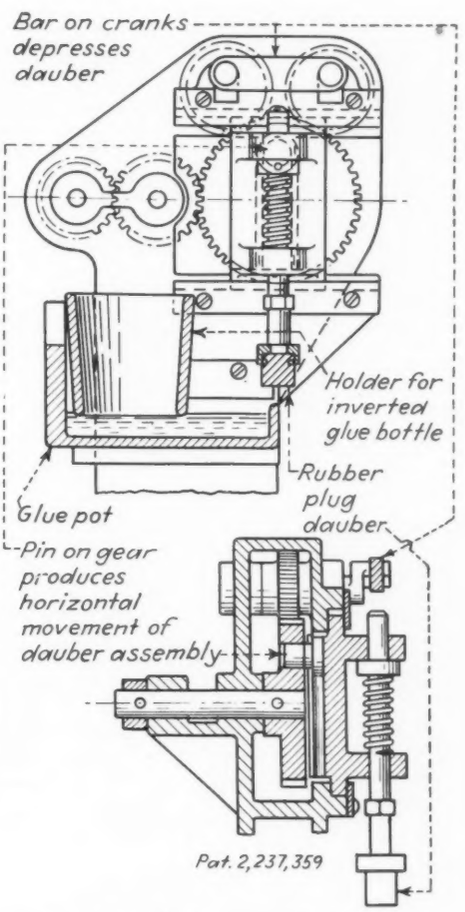
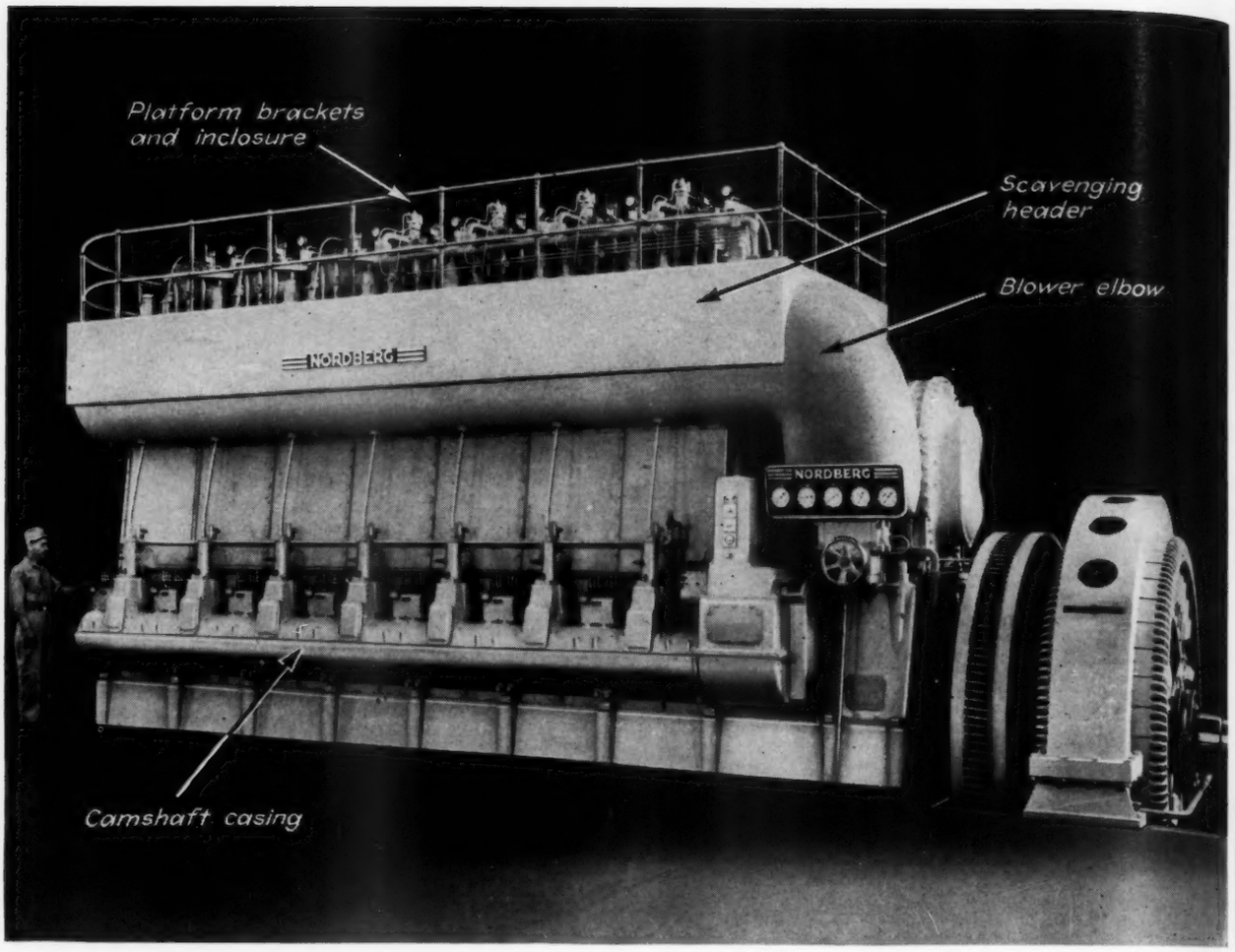

Bar on cranks depresses dauber
Holder for inverted glue bottle
Rubber plug dauber
Glue pot
Pin on gear produces horizontal movement of dauber assembly
Pat. 2,237,359

FIG. 10 – *Dauber assembly is moved horizontally between glue pot and work by eccentric pin on gear. Vertical movements are produced by crank operated bar over dauber shaft*



Arc-welded parts which have been redesigned to improve appearance are indicated on this latest design engine

Arc-Welded Design Helps Reduce Weight of Large Diesel Engines

By using arc-welded construction more and more since 1930 for successive models of large diesel engines Nordberg Manufacturing Company has been able to reduce the weight per horsepower from over 300 lb. to less than 100 lb. Another advantage of the use of arc welding has been the improvement during the past two years in engine appearance without changing the basic structure.

SINCE 1930 Nordberg Manufacturing Company at frequent intervals has improved various design features in its line of large diesel engines. Such a program could not have been followed except for the fact that arc welding was adopted more extensively with each change of model. Had the former type of construction, wherein all main structural members were made of castings, been adhered to the cost of the development program would have been prohibitive. The investment in patterns and the cost of pattern changes would have frozen the design, as is true in the manufacture of most machinery involving large castings; but by changing to arc-welded construction all considerations relative to costs of new patterns, pattern alterations and pattern storage could be discounted. As a result, Nordberg found it economical and profitable to adopt a policy of continuing changes in design, achieving thereby successive models that were each an improvement on its predecessor with respect to weight, cost and appearance.

Perhaps the most important improvement achieved through arc-welded construction was the continuous reduction in weight per horsepower of the successive models. Specifically, whereas in 1930 the weight per horsepower was more than 300 lb., this has been reduced to less

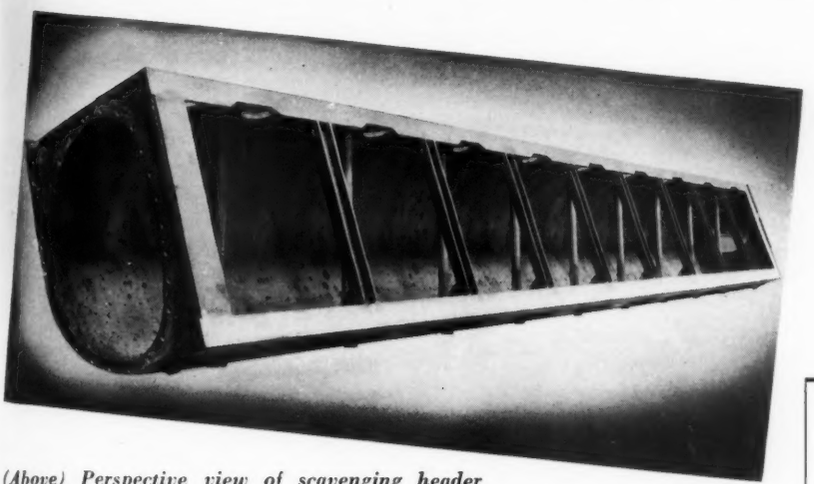
than 100 lb. for engines in the same bore and stroke range. This weight reduction was achieved not by skimping on materials throughout the engine but rather by the redesign of specific castings for arc-welded construction, the welded design being of equal strength and usually of greater rigidity.

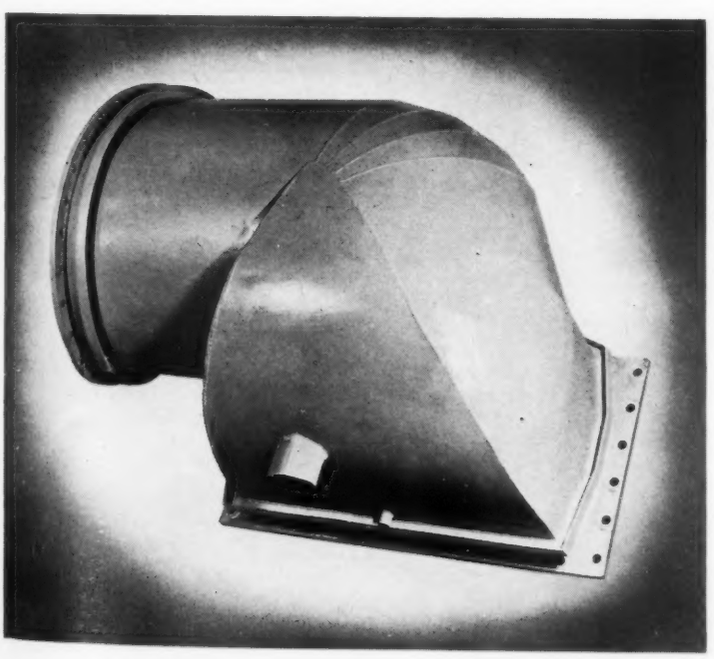
An example of the weight saving achieved by changing from cast to welded construction is the platform bracket. In the older models this was a gray iron casting that weighed 52 lb.; the welded design weighs 25 lb. In this instance the reduction in weight had advantages besides contributing a lower weight per horsepower. The relatively light welded bracket made it possible for two men to lift and bolt in place the welded bracket, whereas the heavy cast bracket required the use of a crane. The saving in crane time is even more significant than the reduction in direct labor cost. In addition, the manufacturing cost of the welded bracket was less than that of the cast bracket.

The main structural frame of the engine consists of a bedplate, columns and cylinder blocks, the whole held together by through tie bolts, producing a structure which acts as a unit in resisting the firing load. Each cylinder block is an individual piece. Joining or connecting these parts longitudinally are the members which serve all cylinders—the scavenging header which supplies air to the cylinders, the camshaft casing, exhaust header and the platforms and railings. In large diesel engines it has been the practice to make the main structure of cast iron practically throughout. However, a thorough analysis of the design by Nordberg engineers indicated that the headers and other parts which run lengthwise were more adaptable to welded construction rather than casting. Over a period of years, following a definite development program, most of the longitudinal members referred to have been redesigned for welding.

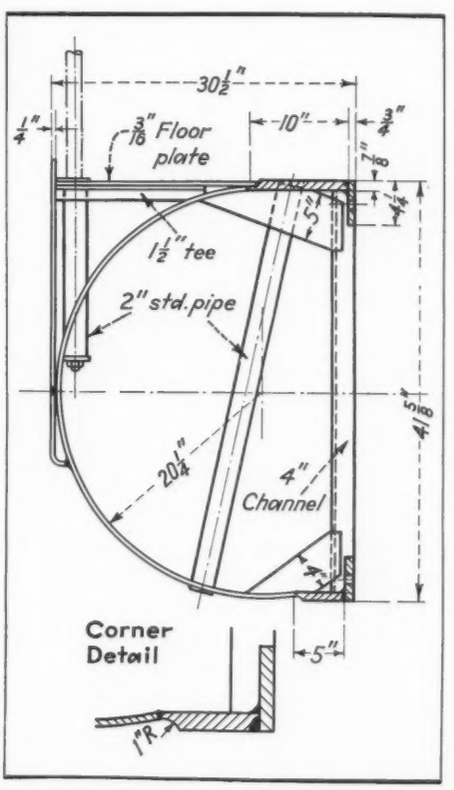
The redesign of the scavenging header, which carries air at low pressure from a blower to the cylinders, presents many interesting problems. Structurally, it must be strong and rigid so that it may be welded, machined and handled as a unit without distortion. It must have sufficient volume so that the pressure does not fall too much as each cylinder takes air; yet it must be light in weight, especially when used for marine engines. Vibrations caused by air pulsations from the blower must be minimized and not transmitted to the header. Also, the design must blend into the general appearance of the engine and seem a part of it, not an accessory.

The main structure of the header consists of a frame, which bolts to the engine cylinders, to which is welded a $\frac{5}{16}$-in. semicircular sheet. This semicircular plate, although light for its size, is inherently rigid by virtue of its form and has the advantage that it is practically unaffected by air pressure pulsations within it. The flat frame is bolted against the rigid cylin-





(Above) Perspective view of scavenging header from side which bolts to engine. (Below) Elbow which connects the blower to the scavenging header



Cross-section of scavenging header recently redesigned for arc-welded construction

der block and is also unaffected.

Carrying out the same principle, the elbow which connects the blower to the header is constructed also of $\frac{5}{16}$-in. plate and is designed with no flat surfaces to vibrate. It is made to conform in shape to the scavenging header and appears in the completed engine to be a part of it.

A peculiar problem had arisen in connection with this piece which was easily solved by a method unique to arc-welded construction. The elbow is bolted rigidly to the scavenging header and is connected to the blower by a flexible joint of ¼-in. soft rubber. It is almost impossible to build up large engines of this type with sufficient accuracy so that the elbow can be prefabricated and drilled with any assurance that it will fit. In order to secure a good match at the header joint and the required fit at the blower, these elbows are torch-cut about 6 in. from the header end just previous to erection. Both joints are then bolted up and the cut rewelded, producing a perfect match at both joints without the necessity of re-machining any parts.

The camshaft casing acts as a support for the camshaft and its drive gear, fuel pumps and cylinder lubricators. It must be rigid enough to take the "bumps" from the fuel pumps, and must be oil tight. The present design requires only three longitudinal welds and has no welds subject to oil leakage. Welding procedure has been simplified and distortion has been much reduced.

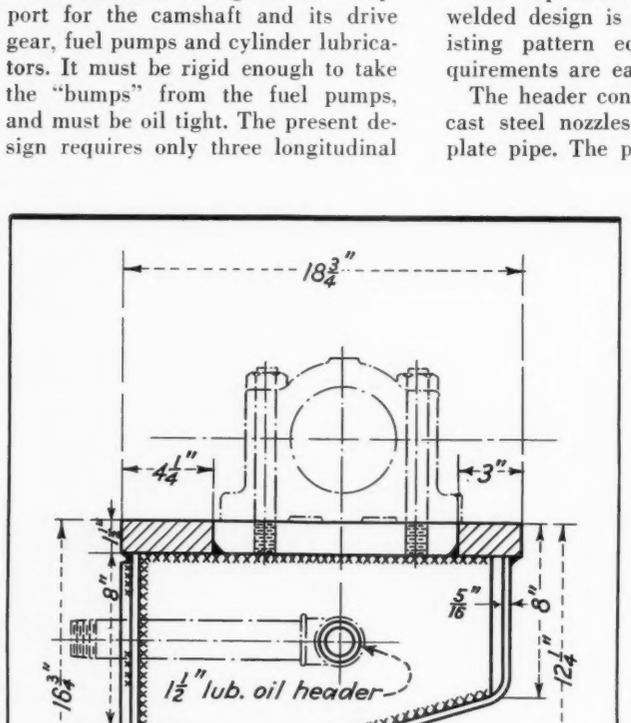
Although the functional requirements of the camshaft casing are easily met, the construction of this long slender weldment presented quite a problem until a definite procedure was evolved. The upper frame is laid down first, upside down, and the gussets attached. The bent plate, angle and pads are then tacked in place. The structure is finished by using a series of welds in sequence established by experience to keep the final assembly straight. This has been developed so that the present design requires only ¼-in. finish allowance on a 34-ft. overall length.

The exhaust header normally presents no great difficulties in welding, but it illustrates the adaptability of welded construction. Each power plant may have a different exhaust pipe layout, to which the engine exhaust must be connected. One may require a connection at the forward end of the engine, another at the generator end. One may require an elbow turned up instead of down. Since welded design is not tied to any existing pattern equipment these requirements are easily met.

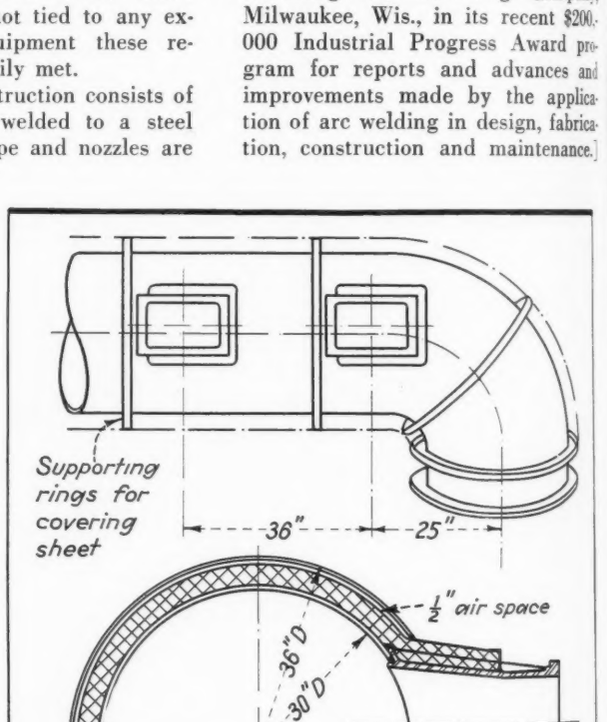
The header construction consists of cast steel nozzles welded to a steel plate pipe. The pipe and nozzles are covered with asbestos cement, then canvas. For protection a $\frac{1}{16}$-in. sheet steel skin is welded over the whole to produce clean appearance. Since the skin remains relatively cool while the pipe reaches a temperature of 500 deg. to 600 deg. F. it is attached to the pipe at the elbow end only, while the other end is free to expand and contract, sliding on supporting rings.

The advantages of arc-welded construction as described here are obvious so far as weight reduction and manufacturing cost savings are concerned. Evaluation of other economic advantages is difficult because of intangibles, such as the increased sales appeal brought about by the "streamlining" of the engines. It is safe to assume, though, that the results of arc-welded construction as far as it has been carried up to the present are satisfactory enough to warrant investigation of further possibilities of this type of construction.

[EDITOR'S NOTE—The data and illustrations are taken from a study submitted to the James F. Lincoln Arc Welding Foundation by Robert Cramer, Jr., assistant chief engineer, Nordberg Manufacturing Company, Milwaukee, Wis., in its recent $200,000 Industrial Progress Award program for reports and advances and improvements made by the application of arc welding in design, fabrication, construction and maintenance.]



Cross-section of latest design of camshaft casing



Exhaust header construction

Industry and Societies

NEWS · READER LETTERS · MEETINGS

Broader Scope of Activities and Longer Training Period Advocated for Engineers

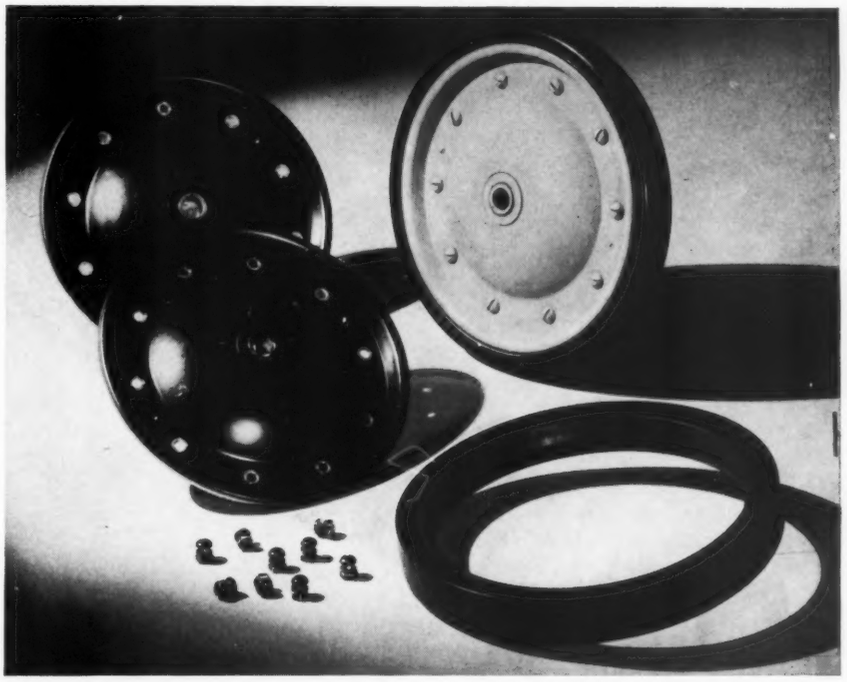
A PLEA FOR BROADENING THE SCOPE of the engineer's activities in the post-war world, and lengthening the period of his training in liberal subjects, was made by Gerard Swope, president of the General Electric Company, when he received the Hoover Medal for 1942 on January 27.

"A knowledge of the growth of industry, and especially the struggle of labor for a larger share of the fruits of production, and a recognition of labor's place in industry, should assist the engineer in taking his rightful place in society and aid him in developing policies that will insure greater good, both materially and spiritually, for the greater number," Mr. Swope said. "The foundation of engineering training is in the exact sciences. The education of the engineer, however, must not be confined to these basic subjects but should include history of the development of man, his industries and his relations with other men, as well as the migration and development of peoples, thus leading to a broader and more tolerant understanding of differences among people.

"Engineering is no longer an extension of a course in manual training, or a study of purely technical subjects; it is a broad profession. Not so long ago neither law nor medicine required a general training in academic or scientific subjects, but now a college course and degree is required before undertaking professional work in these fields.

"The real danger for the engineer is that the fine qualities of the field in which he is working, the exactness of the laws of nature, and the accuracy with which he must determine his design, may easily lead to narrowness of outlook and rigidity in his dealing with men. The tendency of engineers in dealing with human beings is to assume that two and two must always make four. He must be open-minded and liberal in making allowances, that possibly in one case two and two may make only three and seven-eighths and that in another case may make four and one-eighth. The engineer's problem in machine design is to secure stability of structure, efficiency and reliability in operation. The smooth motion and decreased loss from friction that is highly desirable in machines should also be sought after in human relations.

"Society has a right to look to engineers, with their training in accuracy and truth, for leadership in industry, where their services are especially needed to develop assurance of employment, to further progress in simpler design and better methods of manufacturing, the attainment of lower costs resulting in lower prices to the community, and a wider distribution of the products of industry. There is much constructive work to be done to make our communities better places in which to live, to give assurance of work and leisure, without fear, in which to enjoy the benefits of better living, that the ideal of the engineering societies should be con-



Plastic is now being used for treads to replace rubber tires on wheeled restaurant equipment and industrial hand trucks. Resinox, a phenol-formaldehyde compound made by Monsanto Chemical Company, is used. Trucks equipped with these treads on wheels and casters, are made by Jarvis and Jarvis, Inc., Palmer, Mass. The plastic treads roll easily and are simple to attach to a wheel, but they are less resilient and noisier than rubber treads. While the plastic is not suitable for automobile tire use, much rubber can be saved, it is expected, in small wheels and casters.

Lockheed AT-18 trainer which can be used as a gunnery trainer or can be fitted for training in navigation. It is based on the Hudson III. Most of the interior equipment carried by the Hudson has been removed in the trainer, and the cabin stripped down to a shell. There are seats, telephone equipment and regulation radio for a crew of two and one student. A low pressure oxygen system is provided. Each trainer has a target windlass installation which lets the target sock out through the tunnel gun opening. The plane carries a Martin turret in which the student practices firing two 50 caliber machine guns at a target trailed behind another plane.

stantly before us, not only for a political, but also for an economic and industrial democracy."

Willys Jeep Motors Have Many War Uses

BECAUSE OF ITS ABILITY to develop 61 hp. at 3,800 r.p.m., the four-cylinder Willys-Overland Jeep motor is serving at many war tasks. By the armed forces, it is being used to generate power for searchlights, arc welding equipment, short wave transmitters and receivers, and it is coupled to centrifugal water pumps as fire fighting units.

It serves as a power plant in lifeboats and other small craft of the U. S. Marine Corps.

Industry has found it useful for driving tractors. On farms it is serving as the power unit for threshing, cutting wood, and other agricultural chores.

1,000 Small Plants Set To Make Special Tools

FOLLOWING THE LEAD of more than 200 small machine shops in the east now participating in the manufacture of special maintenance tools for combat vehicles, the U. S. Ordnance Department Tank-Automotive Center hopes to utilize the facilities of more than 1,000 small plants throughout the country not now producing war materials.

Special maintenance tools are not standard products of the tool industry. Aside from the fact that some small plants could not produce the entire tool or sets of tools, a portion of the prime contract is being sub-contracted that more small plants may participate in the work. This is part of the new decentralization policy of Maj. Gen. Levin H. Campbell, Jr., Chief of Ordnance.

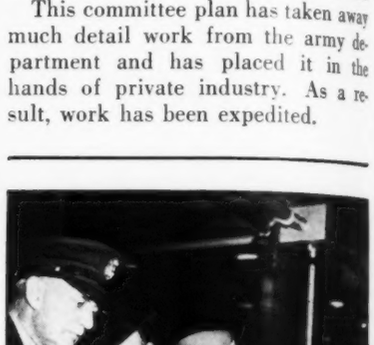
Committee System Speeds Tank Production

AS A MEANS FOR SPEEDING PRODUCTION, manufacturers doing work for the Tank-Automotive Center have organized integration committees for better coordination of manufacturers doing the same type of work. This plan enables members to deal directly with one another in exchanging parts, raw materials, machine tools or better production methods.

Large and small companies all over the United States are members of one or more committees or sub-committees.

Brig. Gen. A. R. Glancy, Deputy Chief of Ordnance in charge of the Tank-Automotive Center, explained that if some manufacturer finds he is getting slow deliveries on some item, the committee office will find out at once if some other manufacturer has an excess of that item so that some balance may be reached. Formerly negotiations were carried on directly with the U. S. Ordnance Department, but now the manufacturer goes to his own committee headquarters, gets the centralized information, and then deals directly with the other manufacturer.

This committee plan has taken away much detail work from the army department and has placed it in the hands of private industry. As a result, work has been expedited.



Turbosuperchargers make possible the performance of the Boeing Flying Fortress and other American high altitude planes. Flaming hot exhaust gases from the engine drive a turbine which in turn drives a compressor for supplying power-producing air to the engine, so that the engine can operate with the thin air of high altitudes. In the photograph, Lieut. Gen. William Knudsen, U.S. Army production chief, and G. E. Berg, superintendent of a General Electric war plant, are inspecting a partly cut away G.E. turbosupercharger.

Men in Armed Services Want Technical Books

TECHNICAL BOOKS published since 1935 in the fields of architecture, aeronautics, chemistry, drawing, machine design, mathematics, meteorology, navigation, photography, physics, radio, shop mechanics and civil and mechanical engineering are being sought by the 1943 Victory Book Cam-

paign, sponsored by the American Library Association, American Red Cross and United Service Organizations, for men in the armed forces.

These men have expressed preference particularly for the types of books listed above, along with lighter reading matter, including best-sellers in the fiction and non-fiction fields. The reasons the soldiers and sailors ask particularly for technical books are to keep up with developments in the fields they left when they went into service and to train themselves for jobs which they may want to seek when the war is over. Public libraries all over the country are the official collection and sorting centers for the campaign.

U.S. May Be in Tin Business After War

ALL THE TIN that the United States needs for war and essential civilian uses can now be supplied by a tin smelter built by the government in Texas. This capacity is almost equal to the anticipated post-war demand, and when present expansion is completed it will be twice that figure. The smelter was built and is being operated for the government by the Tin Processing Corporation, a subsidiary of N. V. Billiton Maatschappij, a Dutch concern. Production at the present time, however, is believed to be a little more than half the existing capacity.

Significance of the existence of the Texas smelter is that it is the only one of any size in the Western Hemisphere, and one of the only two big ones left in the hands of the United Nations. The other smelter is in Liverpool, England. For generations the world has been dependent for metallic tin on British and Dutch interests, which have controlled most deposits of high-grade ore and virtually all of the major refineries through the International Tin Committee.

Deposits of tin ore are found in widely scattered parts of the world, but the richest ores are concentrated in Bolivia, British Malaya and Netherland East Indies. The only ore source now open to the United States is, of course, Bolivia. These ores require hard-rock mining and are of much lower grade than those which come from the Orient.

It is doubtful that the Texas smelter could operate profitably on the present low-grade Bolivian concentrate if it had to meet determined competition from the British and Dutch, assuming that they recover their high-grade deposits in the Orient. However, there are indications that the International Tin Committee is preparing to deal with the United States in the post-war period. The committee now has two delegates from this country, one representing the government and the other representing consumers, but there is no assurance that these delegates will have votes. Significantly, powers to negotiate contracts for foreign purchases, such as tin, now rest with the Board of Economic Warfare, an expert international poker player.

If the United States can induce the Patino interests, which control the better grades of Bolivian ore, to ship to the Texas smelter instead of to Liverpool, this country will be in a strong position to bargain with the committee. The result may well work to the advantage of tin consumption in the United States, which normally takes nearly half of the world output, by possibly lowering prices and increasing availability.

Powered by two 2,000 hp. Pratt & Whitney Double Wasp engines, the Vega Ventura is being manufactured by the Vega Aircraft Corporation, as a big brother to the world famous Hudson bomber. Many planes of the Ventura type have been flown across the Atlantic. The ship has a wing span of 25 ft. 10 in., and an overall length of 57.5 ft. It carries a crew of four persons. All vital parts are protected by machine guns, with a gun in the nose for ground strafing. Many features of this plane's design are still kept confidential, but Venturas are being built on a full time production schedule for use by the British and the U. S. Army and Navy. The Ventura embodies the conventional Lockheed design, and in its appearance closely resembles the Hudson bomber. However, the makers claim the Ventura is "farther, faster, fiercer." Officially, it is a medium attack bomber of the type of North American's B-25 and Martin's B-26.

Discussions and Comments from Readers

BRUCKNER SUPPLEMENTS BERKLEY METHOD FOR DETERMINING WR^2

To the Editor:

The article, "How to Determine WR^2" on pp. 704-706 of December, 1942, PRODUCT ENGINEERING is very useful and timely in these days when factories are being converted and revamped for war production. Also, the author, Mr. Berkley, is to be congratulated on a correct and clear presentation.

However, in some cases the polar inertia of the driven machinery assembly must be determined more accurately than would warrant neglect of such motor factors as the core loss. For example, he obtains a polar inertia of 18,200 by one method and 21,300 by another method, which would not be accurate for most calculations of electrical and mechanical resonance.

Also, in many cases of replacement of old motors, the nameplate data are undecipherable and the motor an orphan. In other cases, the machinery is driven by a steam engine or a turbine. For all such cases, where higher accuracy is required, or the characteristics of the driver are unknown, the following alternative method may be used to find the total WR^2, hence the driven WR^2 by merely subtracting the WR^2 of the driver:

In the first place, the word "deceleration" should be used with cau-

tion, since its literal meaning is to take away from the hastening of", in other words to diminish the rate of acceleration. We are here dealing with a retard.

By adding either a known retarding torque or a known polar inertia to the assembly, and measuring the retard times, we can determine directly the polar inertia with an accuracy not limited by unknown driver characteristics. In most cases, including the illustrations worked out by Mr. Berkley, it is amply accurate to assume a uniform retard from full to ¾ speed, equal to the change in speed divided by the time of retard in seconds.

To illustrate the first method, addition of a known torque: Let x be the unknown friction torque of the entire driving and driven assembly, due to windage and bearing friction, etc. Let t_1 be the seconds to retard to ¾ speed under retarding torque x. Let T be the known added retarding torque, preferably roughly equal to x, consisting of a simple mechanical pony brake. Let t_2 be the seconds to retard to ¾ speed under the combined retarding torque $x + T$.

Then, since the total retarding torques and the measured times are inversely proportional, with closely-parallel torque-time curves over the small range from full to ¾ speed, we have:

$$\frac{x}{t_1} = \frac{x+T}{t_2} \text{ or } xt_2 = xt_1 + Tt_1$$

$$\text{Whence } x = \frac{Tt_1}{t_2 - t_1}$$

Using preferably the larger torque, $x + T$, and larger time, t_2, since these can be measured more accurately, the polar inertia in the lb-ft.^{2} is then merely the above-measured torque divided by gravity-acceleration and by the measured angular retard rate:

$$\text{lb. ft.}^2 = \frac{\text{lb. ft. torque}}{32.2 \times \text{radians/sec./sec.}}$$

Or alternatively, let I_x be the unknown polar inertia to be determined. At any convenient point in the system, add a known polar inertia I_p, such as a scrap flywheel or a pulley picked up around the shop. Let t_1 be the time in seconds to retard from full speed to ¾ speed with I_x and t_2 the time to retard from full speed to ¾ speed with I_x and I_p both effective.

$$\text{Then } \frac{I_x}{t_1} = \frac{I_x + I_p}{t_2}$$

$$\text{Whence } I_x = I_p \times \frac{t_1}{t_2 - t_1}$$

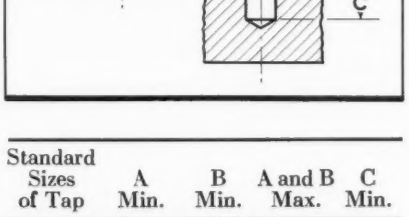
which directly measures the unknown polar inertia without further calculation. The value so found is the polar inertia of the combined driver and driven machinery. If the polar inertia of the driven assembly alone is desired, subtract the polar inertia of the driver. If the driver is an old steam engine with unknown polar inertia, find its individual polar inertia by either of the above methods, whichever is most convenient, by merely disconnecting the driven assembly and adding either a known retarding torque or a known polar inertia.

Of course, where still more accuracy is required, an actual retardation curve can be plotted as explained by Mr. Berkley. This is usually necessary only where the driven assembly retard torque is a power of the speed, as in fan drives. Note that this is not the case where a centrifugal pump is being driven, since we here empty the pump casing for accurate inertia determination. —Robert E. Bruckner

STANDARD FOR DEPTHS OF BLIND TAPPED HOLES ESTABLISHED BY RCA

To the Editor:

Recently there has been some discussion in Product Engineering (August 1942, page 465) on threaded depths of blind tapped holes. Sometime ago standards were established at RCA, for RCA use, giving actual dimensions which can be used on drawings. It is our belief that this is the first time definite figures have been made available on this subject. The RCA standard is as follows:



Standard Sizes of Tap	A Min.	B Min.	A and B Max.	C Min.
#2–56	1/16	3/32	3/16	5/32
#4–40	3/32	1/8	1/4	5/32
#6–32	7/64	9/64	9/32	5/32
#8–32	1/8	11/64	11/32	5/32
#10–24	5/32	3/16	3/8	7/32
#10–32	5/32	3/16	3/8	7/32
#12–24	5/32	7/32	7/16	7/32
1/4–20	3/16	1/4	1/2	1/4
5/16–18	7/32	5/16	5/8	9/32
3/8–16	1/4	3/8	3/4	5/16

Minimum A dimension for metal thickness is based on minimum number of threads required to develop full strength of screw.

Minimum B dimension for depth of full thread is based upon developing full strength of screw and allowing for manufacturing tolerances on screw lengths.

Maximum A and B dimensions are based on maximum depths of tapped holes possible with minimum tool breakage and without special set up. Depths of tapped holes greater than these maximum dimensions may require special processing and inspection equipment. Greater lengths of thread engagement also require special tolerances on lead and pitch diameter of screws and taps.

Minimum C dimension for depth of drilled hole is required to facilitate manufacture and avoid use of bottoming tap. Allowance for this depth should be made, wherever possible, in the design of the part.

—M. S. Gokhale
Standardizing Division
Radio Corporation of America

Meetings

Electrochemical Society — Spring meeting, April 7-10. Hotel Roosevelt, Pittsburgh, Pa.

National Electrical Manufacturers Association—Spring meeting, April 20-23. Palmer House, Chicago, Ill.

American Society of Mechanical Engineers — Spring meeting, April 26-28. Hotel Black Hawk, Davenport, Iowa.

American Society of Mechanical Engineers — Semi-annual meeting, June 14-16. Hotel Biltmore, Los Angeles, Calif.

American Society for Testing Materials—Annual meeting, week beginning June 28, Pittsburgh, Pa., William Penn Hotel.

Do You Know That—

Substitutes have replaced strategic materials in more than 1,000 parts involved in telephone manufacture. Thus, the annual rate of use of aluminum has been cut by 90 percent, crude rubber usage has decreased by 80 percent, zinc by 75 percent and copper by 70 percent. (10)

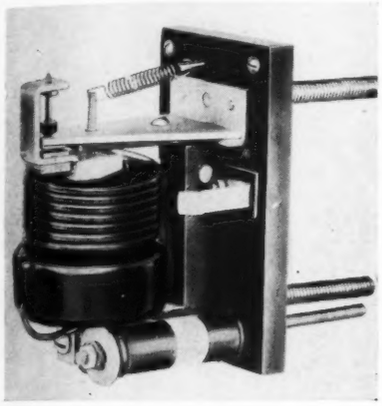
Enough rayon to make 13 dozen pairs of stockings goes into the recoil mechanism of one 37-mm. gun as packing. (11)

Tapered paint brush bristles, formerly obtained only from Oriental sources are now being made of nylon. (12)

New Materials and Parts

Automatic Cutout Relay for Battery Charging

Automatic battery cutout relay, Type HAP, designed for ship service or where batteries are charged from generators. Relay closes the charging circuit when the battery voltage is lower than the voltage of the charging source, similar to the circuit



cutout device in an automobile. When the charging voltage drops to a value below the battery voltage, the cutout relay opens the circuit on a small reverse current. Continuous current ratings available are 2.5, 4, 6.5, 10, 16, 25, 40, 65 and 100 amp., while the voltages range from 7.5 for three-cell batteries to 300 for 120-cell batteries. Relay is designed to function at slightly below the normal charging voltage. General Electric Co., Schenectady, N. Y.

Plastic Coating Prevents Condensation Drip

Condensation caused by differences in temperature and humidity between surfaces and the surrounding air can be prevented with Nodrip, an insulation type plastic cork coating that is effective in the atmospheric temperature range from 0-130 deg. F. The material is not recommended for floors or areas below grade where moisture may be caused by hydrostatic pressure or seepage; for underground pipe lines; for hot water, steam or high temperature lines as a thermal insulation; to prevent sweating inside of cold storage rooms and like areas. Nodrip should be applied at the season of the year when humidity conditions are favorable for proper adhesion and drying. The surfaces to be coated should be dry and not colder than 50 deg. F. nor warmer than 150 deg. F. Application of the coating material may be made by hand, brush, trowel or spray. J. W. Mortell Co., Kankakee, Ill.

Efforts to Save Brass Improve Switch

Redesign of the No. 1010 Levolier switch to conserve brass resulted in improvements that will be incorporated as standard in the line, even after the war. The phenol plastic casing and steel lever combination

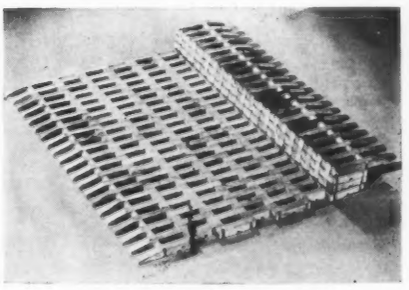
used in the new design were found to be so light and compact that this action is felt to be justified. The switch is rated at 10 amp., 125 volts, and has a special "T" rating, indicating that in addition to standard Underwriters tests, it has had 12,000 more pulls on a load cold, high-wattage, type C lamp with initial surge of 80 amp. This is eight times its rated capacity. McGill Manufacturing Co., Valparaiso, Ind.

Manganese Base Alloy for Instrument Use

More than 70 percent manganese is contained in Chace Manganese Alloy No. 772. An electrolytic manganese with a purity higher than 99.9 percent is used. Manufacturer claims the alloy has a high electrical resistivity, high thermal expansion rate, high vibration damping constant, low thermal conductivity, good ductility and high tensile strength. Electrical resistance is 1,050 ohms per circular mil foot; thermal expansion rate is about twice that for steel; vibration damping constant is 2.3 percent compared to 0.01 for hardened steel. The thermal conductivity is only 2 percent the value for copper. The alloy is available in sheets, strips and rods, and is suitable for rheostats, auxiliary heaters for circuit breakers, and electrically heated expansion elements. W. M. Chace Co., Detroit, Mich.

Link Mat Made From Wood Blocks

Wood blocks 1 in. thick are used to form a flexible wood link matting. Ends of the mat are beveled to reduce the danger of tripping. The mat easily follows the contour of the floor and can be rolled or folded. Stock sizes are 18x32 in., 24x38 in., and 30x44 in. Special sizes of any length and widths up to 36 in. can be obtained. American Mat Corp., Toledo, Ohio.



Crepe Paper Used For Wrapping Ordnance

Ordnance supplies for overseas shipment or storage may be wrapped in greaseproof crepe paper, No. 1A-35. Regulations require that parts greased or slushed with a rust preventive be wrapped with greaseproof paper to hold the preventive on the metal. Pa-

per has a limp, dead quality which, combined with a degree of adhesion, allows the wrapping to conform to the contour of an irregularly shaped object. This limpness, augmented by the characteristic pliability of crepe paper, helps it to form and stretch around corners and edges with reduced risk of tearing and puncturing. Dennison Manufacturing Co., Framingham, Mass.

Line of Test Instruments Is Announced

Because of heavy demands for standard laboratory equipment of the Wheatstone Bridge and decade resistance box type, a new line of such instruments has been announced. Type DR d.c. resistance decades are available in standard models with resistance ranges of 0.9 to 999,999 ohms total and with accuracy of ±1 percent, and 0.1 per-

cent respectively in two classes. All coils are of manganin wire except the 100,000-ohm coils of Nichrome. Coils are bifilar wound on ceramic tubes, oven baked and protectively coated. Switches have self-cleaning multi-blade phosphor bronze spring wipers. Instruments are housed in rubbed walnut cases.

Wheatstone Bridge Type RN-1, illustrated, contains four resistance dials with nine positions each, covering 9x1, 9x10, 9x100 and 9x1,000 ohms, with decade multiplying dials. Ratio resistances have an accuracy of ±0.05 percent, while the resistance coils in the decades of the bridge have a tolerance of ±0.1 percent. Switches and cabinets are the same as for the decade boxes. The galvanometer is a moving coil type with sensitivity of 1 microampere per division. Three standard flashlight cells comprise the 4½ volt battery. Industrial Instruments, Inc., 156 Culver Ave., Jersey City, N. J.

Rubber-Insulated Bushings Make Important Savings

Available for general distribution in the United States for the first time is a new line of rubber-insulated bushings capable of absorbing vibration and shock and of taking torsional and radial movement without lubrication. The bushings have saved important amounts of rubber in different applications without reducing efficiency or life. Known as "Rubberflex," they use a thinner layer of live rubber (or synthetic) than is commonly used. This layer is held between an inner and an outer cylinder of metal by the elesticity of the rubber itself. The bond between the rubber and the metal is mechanical. A saving in rubber is achieved chiefly because the rubber used is molded to the exact length required so that there is no cutting and waste in manufacture. The rubber bushing is of greater outside diameter than the outside cylinder, and smaller inside diameter than the inner cylinder. The relative resistance to slippage on either the inner or outer cylinder can be increased or decreased as required. A wide range of sizes and capacities to suit individual requirements is available. Bushings, Inc., 3447 W. Eleven Mile Ave., Berkely, Mich.

Series of Adhesives Has Vegetable Base

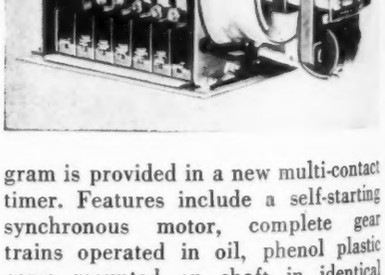
Several grades of Vegimal, a vegetable base adhesive designed for a diversified range of applications, are available. In appearance, Vegimal is a viscous light-tan colored liquid. It is made by conversion of domestic starches with plasticizing chemicals added to produce various drying or setting speeds. At room temperatures, undiluted, it is difficult to spread; heated to approximately 125 deg. F. it liquifies and spreads to a gelatinous cohesive film. Non-warping qualities, shrinkage of film, and duration of "tacky" state can be adjusted by the amount of water dilution, thickness of film, and temperature of solution. It can be applied by automatic gluing mechanisms, hand-brushing, spreading or dipping, and is designed to adhere combinations of paper, cardboard, fabric, leather, imitation leather and similar materials. Paisley Products, Inc., 1770 Canalport Ave., Chicago, Ill.

Semi-Flexible Fabric Resembles Leather

Cottonleather is the name given to multi-ply fabric treated with chemicals to provide density and durability, and surface-treated to give flexibility. Indications are that the new material may be used in place of leather or rubber in many applications. However, it is not now recommended as a replacement for leather belting, since the flexibility at the present time is not adequate for this purpose. Suggested uses are for motor mountings, pipe and hose clamps where metal is objectionable, shock absorbing blocks, heavy shim stock and anti-squeak webbing. It is available in planks, strips and rolls 1 x $\frac{1}{32}$ in. to 6 x $\frac{1}{8}$ in., supplied with one or both sides ground to yield the leathery surface that originally suggested the name. Southern Friction Materials Co., Box 1475, Charlotte, N. C.

Multi-Contact Sequence Timer Is Automatic

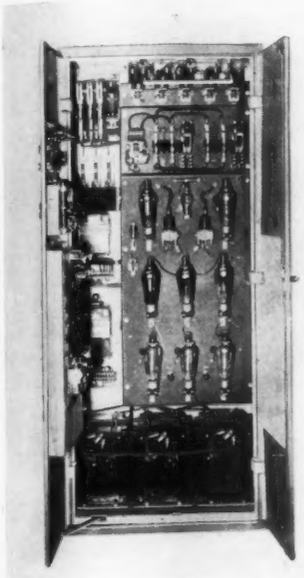
Automatic control of a sequence of "on" and "off" operations of one or more electric circuits in accordance with a predetermined operating pro-



gram is provided in a new multi-contact timer. Features include a self-starting synchronous motor, complete gear trains operated in oil, phenol plastic cams mounted on shaft in identical pairs and contacts in plain view.—R. W. Cramer Company, Centerbrook, Conn.

Electronic Control For Resistance Welding

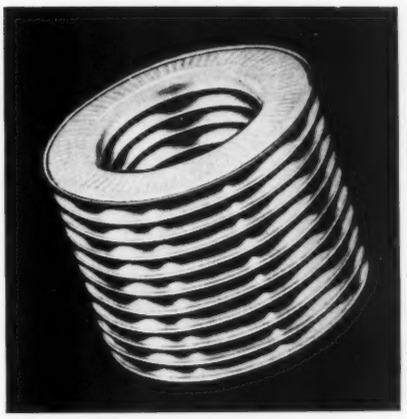
Greatly simplified construction is one of the several important features which characterize a new electronic capacitor discharge control for the resistance welding of aluminum. This construction not only eliminates much vital material but facilities inspection and servicing. Employing the energy-storage principle, the new control performs all the functions for which a control of this type is designed. It consists of a charging circuit, discharge circuit, control station, Pyranol capacitors, and sequence control. This equipment is mounted in a single cabinet with full-length front doors and removable rear covers.



The enclosure is ventilated by filtered air which is drawn in by a blower, creating pressure within the cabinet to minimize the infiltration of dust and dirt. The main anode transformer and all tubes requiring cooling are air-cooled by a ductless system. The charging and discharge-tube circuits are mounted on a single, hinged, compound base that can be swung out for servicing. General Electric Co., Schenectady, N. Y.

Bellows Constructed of Fabricated Diaphragms

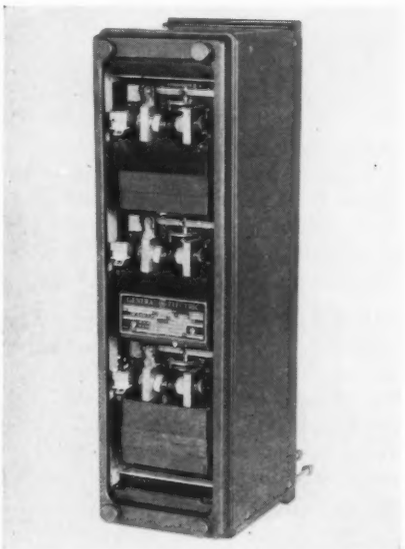
Absorption of hydraulic shock is but one of the applications of "Cook Spring-Life Metal Bellows". The bellows are constructed of individually fabricated diaphragms joined alternately at inside and outside peripheries, enabling the use of spring tempered metals such as phosphor bronze.



steel, and Monel metal. The bellows have been used as an integral part of automatic temperature and altitude control units for assuring proper air and fuel mixtures on aircraft. The makers claim that no bellows has ever ruptured at the joint. Cook Electric Co., 2700 Southport Ave., Chicago, Ill.

High-Speed Relay for Generator Protection

For use in generator protection a new differential relay, Type CFD, has been announced. It is a high-speed, induction-cylinder device, incorporating a new principle called "product restraint" with variable slope characteristics. This combination assures positive operation on internal faults, since the restraining force in case of any single-end-feed condition will be zero or negative because one of the two terms making up the product is zero. The relay is $20\frac{5}{16}$x$5\frac{1}{2}$ in. in the standard three-element drawout case, and can be supplied for surface or semi-flush mounting. Each element of the relay is of the eight-pole, induction-cylinder type. Three poles are used for the differential operating function, and three other poles provide the "product restraint." General Electric Co., Schenectady, N. Y.



Steel Surface Conditioner Shows Acid Saving

Steel surface conditioner and surface brightener, Surbrite, is used to control pickling as a step in reducing acid fume annoyance. It is designed for sulphuric or muriatic acid pickles, and comes in types H and S. Neither form is a wetting agent. Manufacturer claims a high efficiency in acid use and metal saving. Hanson-Van Winkle-Munning Co., Matawan, N. J.

Fast Stabilizing Controller For Process Control

For application where process-lag is considerable, a control function termed Hyper-Reset is available, and is part of the new Model 30 Stabilog Controller. The effects of a process disturbance are reduced by making an initial temporary correction proportional to the rates of change of the measured value caused by the disturbance. The normal reset follows and stabilization is established. The functions are simultaneously and automatically adjusted, with no more than two process adjustments being required. The Foxboro Co., Foxboro, Mass.

Solenoid Starter With Over-Load Protection

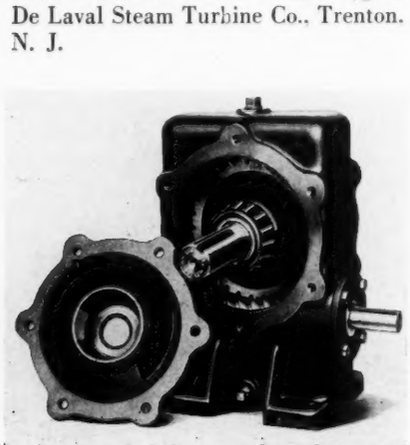
Full overload protection is provided in the "Thermaload V Solenoid Motor Starter." The trip always occurs within the same time at a given per-

centage of overload. It is impossible for the operator to hold the starter button in the "On" position which would prevent the trip when the overload occurs. The button must be pressed and then released before contact is made. A resilient, shockproof mounting eliminates objectionable hum; double-break contacts are of

pure silver, and coils are interchangeable for different voltages. It is available in five sizes from 1.5 to 7.5 hp., and from 110 to 550 volts a.c. The size is 5¾x5¼x4⅛-in. Monitor Controller Co., Baltimore, Md.

Small Worm Gears for Low Power Units

Small worm and worm gear sets, are made for small high-speed electric motors to operate units requiring a small amount of power. The casing, with side plates, inclose the working parts and serves also as a reservoir for oil to lubricate the bearing and gears. Ball bearings carry the worm shaft, and Timken bearings the wheel shaft. Units come with either top or bottom drive, with shaft extension to right or left, or in both directions; for ratios of 3⅝ to 1 up to 60 tol, and center distances of 3 and 3½-in. De Laval Steam Turbine Co., Trenton. N. J.



Manufacturers' Publications

STAINLESS STEELS — Carpenter Steel Co., Reading, Pa. Booklet, 98 pages. Complete and detailed information on selection, engineering and fabrication of Carpenter stainless steels is contained in this attractive book. Any designer who is interested in stainless steel in either war production or post-war planning should have this material in his library.

ARC - WELDING EQUIPMENT — Harnischfeger Corp., Milwaukee, Wis. Bulletin W-20, 12 pages. The position of arc-welding today is compared with the place where steel was ten years ago in this interesting discussion of advances in the design of arc-welding equipment.

CONTROL INSTRUMENTS—Bristol Co., Waterbury, Conn. Binder of bulletins. Automatic control and recording instruments for industrial furnaces, kilns, and ovens are described. The bulletins are well illustrated with application drawings, photographs and wiring diagrams. Data indicate a wide selection of types and combinations.

INDUSTRIAL RUBBER—B. F. Goodrich Co., Akron, Ohio. Catalog section 7020, 8 pages. To assist those responsible for the purchase of industrial molded rubber goods is the purpose of this publication. Questions and answers on molds and mold cavities, discussion of mold costs, materials of which molds are made, tolerance limits in manufacturing molded rubber goods, attachment of rubber to metals in molding and the shape of molded products are covered.

CIRCUIT BREAKERS — Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. Booklet, 40 pages. How to select the De-ion circuit breaker best suited for an application is included in this catalog of the company's complete line of such devices, along with diagrams showing the exact size of each breaker.

VALVES — Watson-Stillman Co., Roselle, N. J. Manual, 36 pages. Each unit in the company's line of bronze, forged steel and cast steel globe and check valves is described and illustrated. Several new types are announced in this manual.

BRUSH SPRINGS — Instrument Specialties Co., Dept. K, Little Falls, N. Y. Bulletin 5, 12 pages. Part 1, for the user of brush springs, gives information on Micro-processed beryllium copper brush springs. Part 2 includes data and formulas for designing Micro-processed brush springs for longer life.

INSTRUMENTS—Foxboro Co., Foxboro, Mass. Catalog 95-A. 48 pages. Six of the ten sections in this catalog describe the instruments, accessories and supplies appropriate for particular applications, such as temperature, flow, pressure, level and humidity. The remaining sections cover combination instruments, valves, instrument panels and similar subjects.

POWER TRANSMISSION — Ramsey Chain Co., Albany, N. Y. Catalog 642, 64 pages. Engineering information on the design and application of Ramsey silent chain drives and flexible couplings is presented.

SPEED REDUCERS—Janette Manufacturing Co., 556 West Monroe St., Chicago, Ill. Bulletin 22-27, 100 pages. Detailed information on the company's line of speed reducers is given, including modifications, dimensions and mounting data.

PILOT LIGHTS—Gothard Manufacturing Co., Springfield, Ill. Catalog, 8 pages. Assemblies for marine, aircraft, signal corps and industrial applications are shown. Material includes types, sizes and diagrams.

CONTROLS—Square D Co., Dept. 21, 4041 North Richards Street, Milwaukee, Wis. Catalog, 48 pages. Detailed descriptive and engineering information on control devices such as circuit breakers, switches, relays, contactors, push buttons, limit switches and special purpose devices made by this company for many types of mobile equipment are described.

COOLANT PUMPS—Ruthman Machinery Co., Cincinnati, Ohio. File data. Types and sizes from 1/30 to 2 hp. and capacities up to 200 gal. per min. of Gusher coolant pumps are described in detail.

HOLDING DEVICES — Anker-Holth Manufacturing Co., McCormick Building, Chicago, Ill. Bulletin, 28 pages. Airgrip pneumatic and hydraulic holding devices are described completely. Illustrations are included.

Books and Bulletins

Plastics Catalog—1943

PLASTICS CATALOGUE CORPORATION—*864 pages, 8¾x11⅝ in. Blue-cloth covers. Published by Plastics Catalogue Corp., New York, N. Y. Price* $5.

This book presents the latest results of research and manufacturing processes in the field of plastics. As compared with the 1942 volume, the number of pages was increased 40 percent and two new sections were added to serve the wider uses of plastics. These new sections are Laminates and Plywood, and Rubber-Like Plastics.

To simplify use as a reference book, material has been grouped into the headings of plastics in war, materials, plastic materials manufacturing, molding and fabrication, machinery and equipment, finishing and assembly, laminates and plywood, coatings, synthetic fibres, rubber-like plastics, and index and directories.

A large number of photographs have been reproduced to show the latest use of plastics and the newest in manufacturing methods.

Twelve pages are devoted to a history of plastics which goes back to the work of Henri Bracconot in 1832. The period from 1940 on, has opened an immense field for the use of plastics. Global warfare has called for new applications. The book shows how the industry has met this challenge and opportunity.

Super-Electricity

RAYMOND F. YATES—*165 pages, 5x7½ in., 39 illustrations. Blue cloth-board covers. Published by D. Appleton-Century Co., 35 West 32nd St., New York, N. Y. Price* $2.00.

Anyone even remotely interested in electronics should read this book. It is written primarily to explain the field to young people of high-school age, or older persons who might be considering a career in a branch of electronics, and does this job very well. The book opens with a brief history of electronics and goes on to explain the fundamentals of photocells in a surprisingly lucid manner. How to build simple and crude, but effective, electron tubes in the home workshop is covered thoroughly. Then the author goes into a discussion of what electron tubes are used for in various branches of industry and how a person can set himself up in business. Finally, the opportunities for gaining an education in this "infant" of the electrical profession are thoroughly explained.

At times, the author is almost overoptimistic in his enthusiasm for his chosen field. This is perhaps only natural, though, for a person who is in the unique position of having started his life work in an industry at the time that that industry was just beginning to come into its own. The author's flowing style makes pleasant reading of what might easily have been a dull treatment of a very interesting subject.

How to "Think Up"

ALEX OSBORN—*38 pages, 5x7⅝ in. Published by McGraw-Hill Book Co., 330 West 42nd St., New York, N. Y. Price 50 cents with board covers, 25 cents with paper covers.*

Although this work was written to draw out more ideas from the 500 people in the advertising firm of Batten, Barton, Durstine & Osborn, the material in it goes a lot further than merely how to get ideas from employees. Suggestion systems are covered in a general way but the meat is in the author's description of how to get ideas and then what to do with them. This book would be most helpful to those with "routine" jobs, but people whose work is "creative" could also benefit by reading it.

Lubrication

ARTHUR E. NORTON—*244 pages, 6x9 in. Published by McGraw-Hill Book Co., 330 West 42nd St., New York, N. Y. Price* $3.

The object of this book is to give engineers a background of the basic theory of lubrication that will enable them to understand better the frequent technical papers on the subject. The book is also felt to be well suited for classroom instruction. The material was taken from notes used by the late Prof. Norton at the end of eight years of teaching a course in lubrication and bearings at Harvard University. J. R. Muenger was the editor.

A large portion of the book is concerned with the hydrodynamic theory of bearings and is developed from simple concepts of viscosity and equilibrium rather than from the equations for motion and equilibrium. Types of friction and their relation to bearings and lubrication are discussed as well as design practices and methods of applying lubricants. A chapter is devoted to lubricant properties. Friction and anti-friction bearings are compared.

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Electric Arc Welding Machine and Electrode Standards

Prepared and published by the National Electrical Manufacturers Association, 155 East 44th St., New York, N. Y. Publication No. 42-81. 29 pages 8x10½. Price 75 cents.

This handbook takes the place of No. 36-37 issued in 1936 on the same subject. New material covers standards for both a.c. and d.c. arc welders. Standards for rectifier arc welder equipment are very much the same. Changes and additions to the d.c. welder section cover service conditions, motor starting and generator control equipment, current ratings and current adjustment of multiple operator welding circuit control panels and resistors, and reactors for use with these panels. Changes or additions to the a.c. welder section include temperature rise, range of operation, current adjustment, short circuit current, control apparatus, panels, terminals, housing, and dielectric tests. There is a separate section for standards for electrodes.

Charts for Computation of Stresses in Foundations

NATHAN M. NEWMARK—*28 pages, 8 illustrations, 2 tables, 3 supplementary influence charts, 6x9 in. Published by the University of Illinois, Urbana, Ill.*

This is Bulletin No. 338, "Influence Charts for Computation of Stresses in Elastic Foundations," issued by the Engineering Experiment Station of the University of Illinois, and describes a graphic procedure for computing stresses in the interior of an elastic, homogeneous, isotropic solid bounded by a plane surface and loaded by distributed vertical loads at the surface. The stresses are computed from the supplementary influence charts by counting on a chart the number of elements of area, or blocks, covered by a plan of the loaded area drawn to proper scale and laid upon the chart. The charts are for computing, respectively, the vertical stress on horizontal planes, the horizontal stress on vertical planes, the sum of the principal stresses, the horizontal shearing stress on horizontal planes, the horizontal shearing stress on vertical planes and corrections for variations in Poisson's ratio.

Moment of Inertia, Section Modulus And Radius of Gyration Of a Rectangular Section Turned at Any Angle

THE SET OF NOMOGRAMS on the following two pages enable a quick determination of section properties of a rectangular section at any angle. The equations for these properties are:

Moment of Inertia - - - $I = \frac{bd}{12}(d^2 \cos^2 a + b^2 \sin^2 a)$

where b, d, and a are section dimensions, as indicated on the diagram with Chart 1. This equation may be written, for convenience in nomographic solution:

$$I = \frac{bd^3}{12}\left(\cos^2 a + \frac{b^2}{d^2}\sin^2 a\right) \quad (1)$$

The distance y, shown on the diagram, may be expressed:

$$y = \tfrac{1}{2}(d \cos a + b \sin a) = \tfrac{1}{2}b\left(\frac{d}{b}\cos a + \sin a\right)$$

Section Modulus - - - $Z = I/y = \frac{d^3}{6}\frac{\cos^2 a + (b/d)^2 \sin^2 a}{(d/b)\cos a + \sin a}$ (2)

Radius of Gyration - - - $r = \sqrt{I/A}$

$$r^2 = \frac{d^2}{12}\left(\cos^2 a + \frac{b^2}{d^2}\sin^2 a\right) \quad (3)$$

Letting $M = \cos^2 a + \left(\frac{b}{d}\right)^2 \sin^2 a$ and $N = \frac{d}{b}\cos a + \sin a$

Equations (1), (2) and (3) may be written:

$$\frac{12I}{b} = Md^3 \quad (4)$$

$$6ZN = Md^3 \quad (5)$$

$$12r^2 = Md^2 \quad (6)$$

The first chart is used to determine M and N. Two nomograms are used because of necessary differences in scales for the ratio of section dimensions and its angle. To use these nomograms the ratio d/b must be computed first. This can be done nomographically, if desired, on the second chart by drawing a line or laying a straight edge across the d and b scales and reading the value of d/b on the N-scale line.

In the example given for illustration, d=9 in., b=4.5 in. and a=45 deg. Lines across the proper scales at these values give M=0.625 and N=2.12.

The desired properties of the rectangular section are determined on Chart 2. Line 1 on this chart between 0.625 on the M-scale and 9 on the d-scale solves Equation (6) and determines the radius of gyration: r=2.05. It also locates a turning point on the unscaled vertical line.

Line 2 through the turning point and 4.5 on the b-scale solves Equation (4) and determines the moment of inertia: I=171

Line 3 through the turning point and 2.12 on the N-scale solves Equation (5) and determines section modulus: Z=35.8

Check:

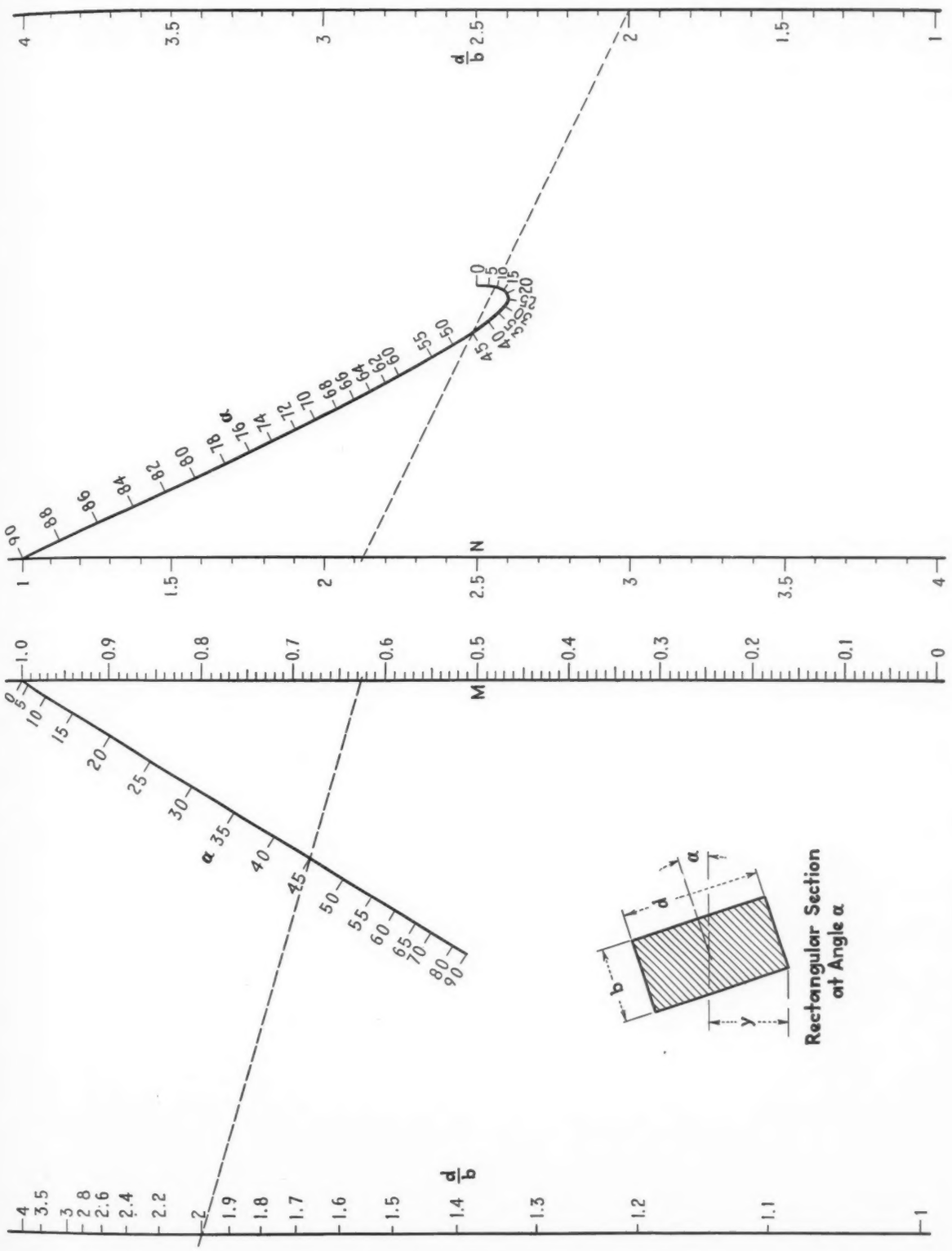
$$I = \frac{4.5 \times 9}{12}(9^2 \cos^2 45 + 4.5^2 \sin^2 45)$$
$$= 3.375\,(81 \times 0.5 + 20.25 \times 0.5)$$
$$= 171$$
$$Z = I/y = 171/\tfrac{1}{2}(9 \cos 45 + 4.5 \sin 45)$$
$$= 342/(6.363 + 3.18)$$
$$= 35.8$$
$$r = \sqrt{I/db} = \sqrt{171/(9 \times 4.5)} = 2.05$$

As a second example let d=6, b=4.25, and a=30 deg. The ratio d/b=1.412. When these values are applied to Chart 1, the values of M=0.875 and N=1.743 are obtained. Line 1 on Chart 2 would then give r=162, line 2 would give I=66.9, and line 3 would give Z=18.1, one or all of which may be desired.

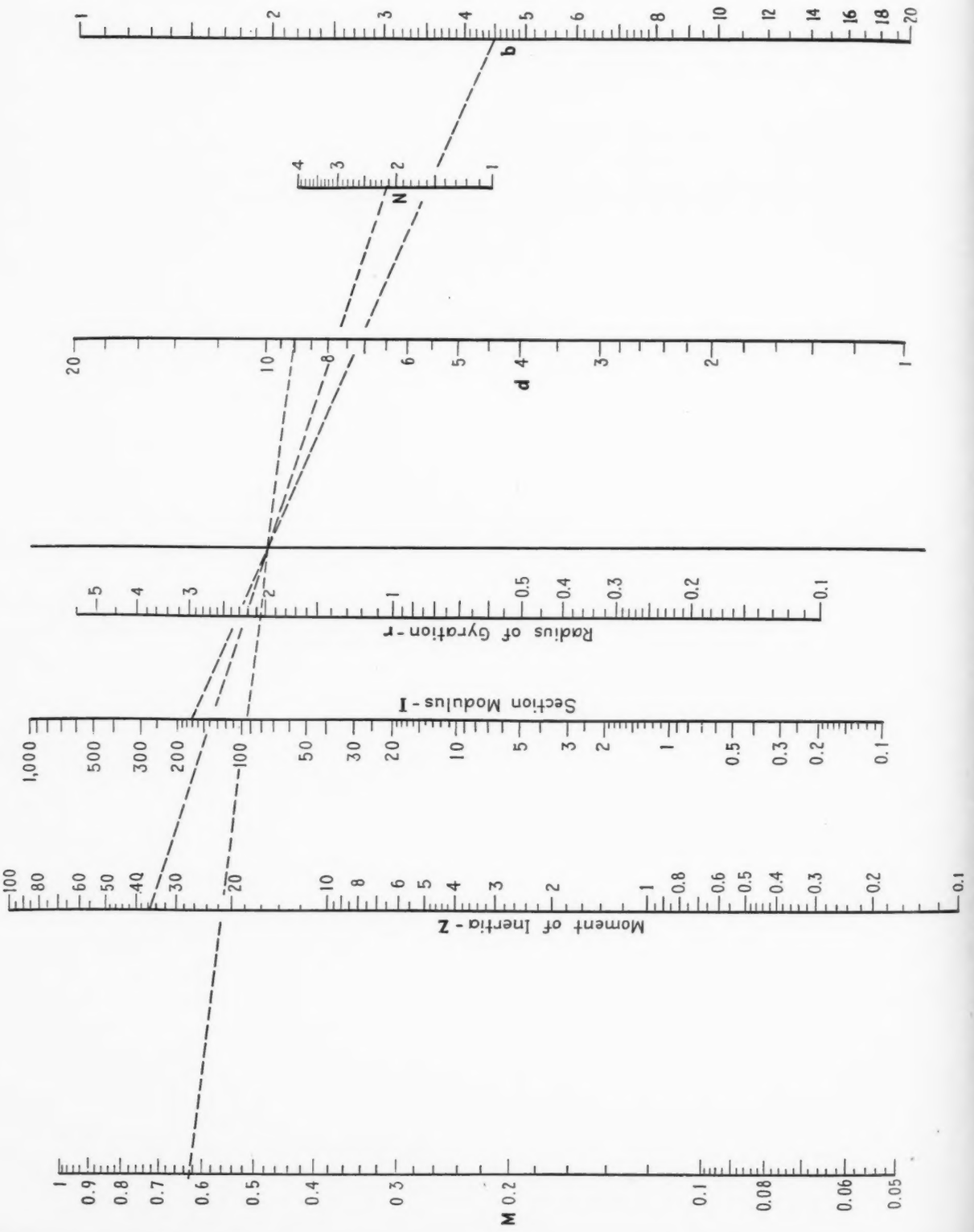
By inspection of Equations (4), (5) and (6) it is obvious that maximum and minimum values of I and r occur when M is maximum and minimum respectively, and when the angle a=0 and 90 deg. respectively. Maximum and minimum values of Z occur when the ratio M/N are maximum and minimum respectively. Maximum occurs when a=0 for example 1 but the minimum value is not so readily obvious. It can be approximated by trying various positions of the solution lines with a slide rule to compute ratios of M/N, when determined on the chart.

The values of M and N, being functions of b, d and the angle, take into account the dimensions of the rectangular section, which, within the limits of this chart, do not include values of depth d less than width.

Properties of Rectangular Sections at Any Angle



Properties of Rectangular Sections at Any Angle



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